JAN 2 1946

SURGERY Gynecology and Obstetrics

With International Abstract of Surgery

VOLUME 82 January, 1946 NUMBER 1

Dietary Protein after Surgery and Other Trauma

apparently must be maintained at a level above normal in order to assure proper wound healing* and at least average resistance against infection. The feeding of meat, therefore, in adequate amounts, as soon as it can be instituted, appears doubly advantageous: the protein content of meat is high and of highest biologic value; the human digestive tract appears well adapted for handling meat protein.****

*"... in a variety of medical and surgical conditions there may occur a considerable depletion of body protein owing to a combination of factors, of which the two most important are a generally diminished protein intake and an enhanced protein catabolism. This situation inhibits wound healing, renders the liver more liable to toxic damage, impedes the regeneration of hemoglobin, prevents the resumption of normal gastrointestinal activity and delays the full return of muscular strength. It is obvious that to meet the situation an adequate supply of proteins and calories must be made available to the body.... This implies at least 150 Gm. of protein and 3500 calories, with as much as 500 Gm. of protein daily when trauma has been severe, as in serious burns." (HOFF, H. E.: Physiology, New England J. of Med. 231:492 [Oct. 5] 1944.)

**"Cannon ... cites the evidence which indicates that diminished protein intake lowers resistance to infectious disease, and corroborates it by his own experiments ... it seems probable that the small intestine is better adapted for handling protein (especially meat protein) than for other types of food.... It is especially well supplied with enzymes which attack protein, and the digestion of meat has been shown to be more complete than that of foods of vegetable origins." (CRANDALL, L. A., Jr.: The Clinical Significance of the Plasma Proteins, Memphis Med. J. XIX:147 [Oct.] 1944.)

The Seal of Acceptance denotes that the nutritional statements made in this advertisement are acceptable to the Council on Foods and Nutrition of the American Medical Association.

AMERICAN MEAT INSTITUTE

MAIN OFFICE, CHICAGO ... MEMBERS THROUGHOUT THE UNITED STATES

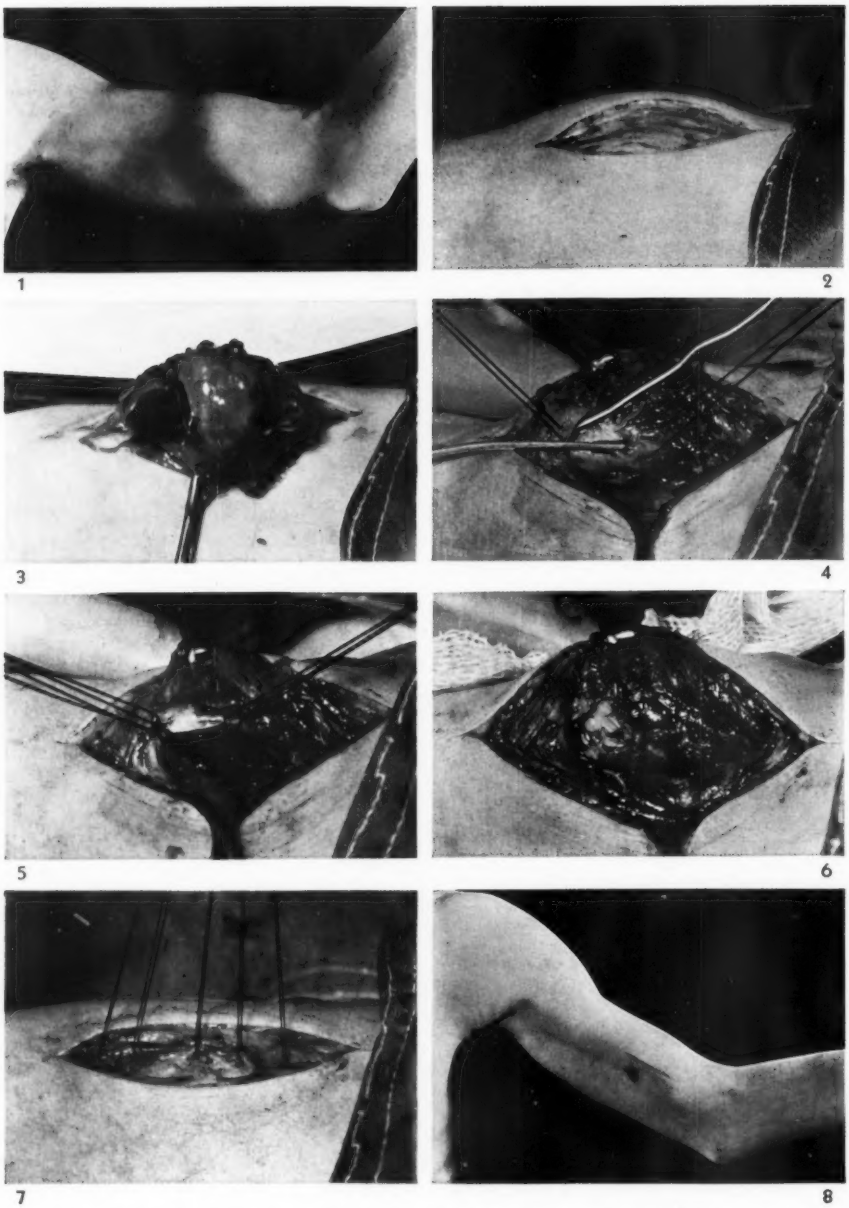


Plate A—The Matas operation: 1. Aneurysm of brachial artery. 2. The sac exposed. 3. The sac open and the clot evacuated. 4. Openings in the sac identified by probes and sutures passed around the vessels. 5. Two openings have been closed with ligatures. 6. Tourniquet has been removed. No bleeding from the vessels. 7. Deep fascia is closed. 8. Incision is closed.

Traumatic Aneurysm.—Daniel C. Elkin.

UNIV. OF MICH.

Medical Lib.
Wash

SURGERY
GYNECOLOGY AND OBSTETRICS
An International Magazine, Published Monthly

VOLUME 82 JANUARY, 1946 NUMBER 1

TRAUMATIC ANEURYSM

The Matas Operation—Fifty-Seven Years After

DANIEL C. ELKIN, M.D., F.A.C.S., Colonel, M.C., A.U.S.,
White Sulphur Springs, West Virginia

THE report of the first patient treated by endoaneurysmorrhaphy was made by Dr. Rudolph Matas in the *Philadelphia Medical News*, October 27, 1888. In the 57 years which have intervened since that memorable publication no alterations in the technique of the procedure other than minor niceties have been made. Few operations have stood this test of time, and none has had a more profound effect upon the surgery of blood vessels.

Dr. Matas has recorded the story of his first operation as follows:

"On April 6, 1888, I operated upon a young male Negro for a very large traumatic (multiple gunshot) aneurysm of the brachial artery, extending from the armpit to the elbow, which opened my eyes to the possibilities of an entirely new method of conservative treatment which was to revolutionize my previous notions of aneurysmal surgery. In this case, the successive ligation of the main artery on the proximal and distal poles of the aneurysm had been followed by relapse, and it seemed to me, then, that I had no other alternative but to extirpate the sac. When I exposed the sac and emptied its contents, the failure of the ligations to control the circulation was easily explained by the appearance in the bottom of the sac of three large orifices corresponding to the collateral branches which opened into the sac in the segment of the artery included between the ligatures (Fig. 1). It was evident that it was these collateral orifices that fed the sac despite the ligatures that had been placed at each one of its poles. I, at first, intended to secure these collaterals by excising the sac, but the branches of the brachial plexus of nerves were so densely incorporated in its walls that I could not have dissected them out and detached them, without serious damage, thereby paralyzing the arm. It occurred to me then that the easiest way out of this awkward dilemma was to seal the orifices of all the bleeding collaterals by suturing them as we would an intestinal wound, leaving the sac attached and undisturbed in the wound. This procedure was at once put into effect and the hemostasis was so perfect and satisfactory that it seemed to me strange that no one should have thought of so simple an expedient before."

From the Vascular Surgery Center, Ashford General Hospital, White Sulphur Springs, West Virginia.

Prior to the introduction of this procedure, aneurysms were treated by a variety of methods, most of them unsuccessful. Compression by various methods (digital, bandaging, instrumental) and the introduction of sclerosing and coagulating agents were employed. Older operative methods included that of Antyllus (fourth century A.D.) which consisted of ligation of the vessel above and below the sac, the evacuation of its contents and the application of an astringent or of packing. Anel's operation (1710) consisted of ligation of the proximal artery close to the sac. One-half century later, John Hunter tied the femoral artery in the canal which bears his name for aneurysm of the popliteal artery. It was Hunter's idea to bring clotting and eventual cure of the aneurysm and at the same time preserve a collateral circulation. In this

he was highly successful except for the frequent recurrences which took place through the circulation which he was so anxious to preserve. As has been pointed out by Homans, since Hunter's time "the preservation of the collateral circulation has become an essential part of every curative procedure." It is upon this theory that the Matas endoaneurysmorrhaphy is based. Later Brasdor and Wardrop independently ligated the artery or one of its principal branches on the distal side of the sac in an attempt to arrest the circulation through it. These procedures were at best a makeshift and were usually performed only when the position of the aneurysm prevented other forms of treatment. In many instances amputations were performed for the relief of pain and in order to prevent an almost certain eventual fatal hemorrhage. All of these methods, with the exception of the Matas procedure, were frequently followed by infection, hemorrhage, gangrene, or failure to cure the condition (Fig. 2).

The incidence of multiple injuries in the present war as a result of high explosive shells, grenades, and antipersonnel mines has led to the production of a larger number of vascular injuries than in any other conflict. While small fragments are more apt to cause arteriovenous fistulas, many produce false aneurysms as well, and to many of these the principle of intrasaccular closure is applicable. In cases in which the aneurysm is large and in which its dissection would unquestionably result in damage to surrounding structures such as muscles, nerves, and other blood vessels, the Matas operation is certainly the procedure of choice. It is difficult to employ in a small aneurysm or where the lesion is accompanied by nerve damage. Here the passage of sutures may damage neural structures, and it is better to carry out neurolysis or nerve suture as a single procedure with excision of the aneurysm. However, the principle of intrasaccular suture may well be applied to those instances of arteriovenous aneurysm in which a large venous sac is present as in Case 8 (Fig. 3).

The endoaneurysmorrhaphy of Matas is simple in conception, and, if the principles of its application are borne in mind, it is extremely easy to carry out. Wherever possible a tourniquet should be applied before the sac is opened, but if this is precluded by the position of the aneurysm, temporary occlusion of the proximal vessel, as shown in Cases 1, 2, and 3, is of aid in performing the operation in a less bloody field. As soon as the sac is opened and its clot is evacuated, search should be made for the openings in the artery into the aneurysm. If not readily found, temporary loosening of the tourniquet will disclose their position. Usually one or two figure-of-eight sutures of medium silk are sufficient to close the openings, but if any bleeding occurs following removal of the tourniquet these can be re-enforced by the placing of other sutures (Fig. 4). Actual obliteration of the sac by sutures is difficult because of its friable nature, and any suture is apt to cut through. When bleeding is controlled and the clot, including the laminations, is removed, the sac will readily collapse and its walls coalesce with the application of a snug elastic bandage. In some instances, the proximal and distal vessels can be dissected from surrounding structures within the sac and individually ligated (Fig. 4). When this is done there is less danger of injuring concomitant veins or neural structures, and the vessels are ligated with more confidence.

One hundred and six instances of false aneurysm have been treated by operation at this hospital in the past 30 months: in 61 the Matas procedure has been employed, and in 45 some other type of operation, usually complete excision of a small sac, has been the method used. The location of the lesions treated by intrasaccular suture is shown in Table I.

Results. There have been no deaths in this series, no recurrence, and no instance of gangrene. Sympathetic interruption has not been practiced either before or after operation, but it is admittedly a valuable adjunct in increasing blood flow in the presence of ischemia. Careful tests for evaluating collateral circulation were routinely carried out before the operation and when it appeared that the circulation was impaired, compression of the vessel proximal to the aneurysm was carried out for some

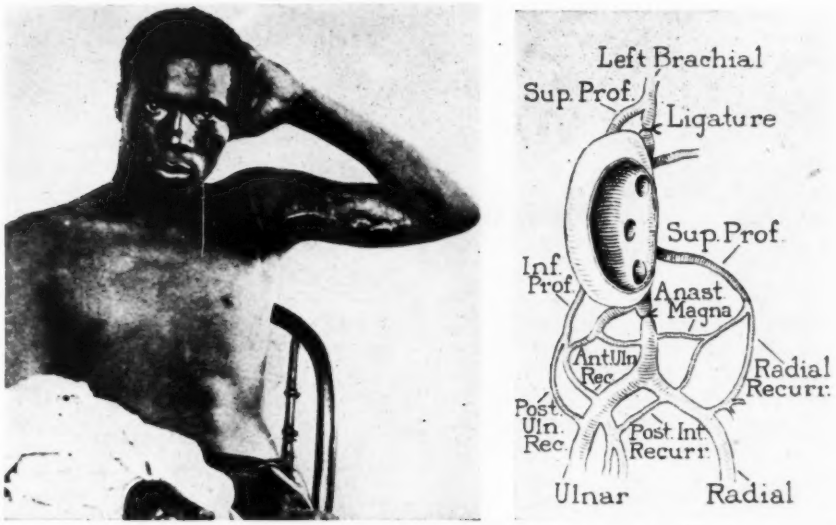


Fig. 1. The original photograph and drawing shown in report of Dr. Matas, *Philadelphia Medical News*, October 27, 1888.

time before operation. In general, it was believed that if a period of 3 months had elapsed between injury and operation, adequate collateral flow had been established. This feeling has been justified in view of the results.

ILLUSTRATIVE CASES

CASE 1. False aneurysm, left gluteal artery, due to high explosive shell fragment wound incurred February 27, 1945. Extraperitoneal temporary occlusion of common iliac artery. Endoaneurysmorrhaphy, superior gluteal artery, June 8, 1945. Recovery.

This 26 year old soldier received multiple wounds in the region of the left hip from high explosive shell fragments. Bleeding was not profuse. Because of abdominal pain and swelling in his hip region and the presence of an abdominal mass which could be palpated by rectum, an operation was performed in England on April 12, 1945, at which time the left internal iliac artery was ligated. There was some improvement in his symptoms but in the 30 days prior to admission to Ashford General hospital on June 3, there was increased swelling in the left hip and buttock with severe pain controlled only by morphine. On admission there was a large soft mass over the whole left hip region, extending as far medially as the sacrum (Fig. 5,a). There was a small healed wound in the center of this massive swelling. Directly over the mass a systolic murmur could be heard and the mass pulsated synchronously with the heart beat.

On June 8, 1945, operation was performed under continuous spinal anesthesia. The common iliac artery was exposed through an extraperitoneal incision and a ligature was passed around it which was not tied and the vessel was temporarily occluded with an artery clamp. A vertical incision was then made directly over the center of the aneurysm (Fig. 5,b), and clot measuring 700 cubic centimeters in volume was evacuated. With removal of the clot there was considerable bleeding which was found to come from two openings in the superior gluteal artery about 1.5 centimeters apart. Both openings were closed with two figure-of-eight sutures with complete control of the bleeding. The clamp previously placed on the common iliac artery was then removed, which caused some bleeding from the muscles and skin which was easily controlled. Both wounds were then closed in layers with interrupted sutures of silk. His recovery was without event and the pain previously complained of rapidly disappeared.

CASE 2. False aneurysm, right femoral artery, due to high explosive shell fragment wound incurred July 5, 1944. Endoaneurysmorrhaphy, August 13, 1944. Recovery.

This 26 year old soldier was struck by high explosive shell fragments on July 5, 1944. He received multiple wounds of both legs. While in an evacuation hospital, he had three hemorrhages from wounds of the left leg and on July 17, 1944, one was so severe as to require ligation of the left posterior tibial artery and vein. Since the time of the original wounds, he had noticed gradual enlargement of the right anterior thigh region which continued to in-

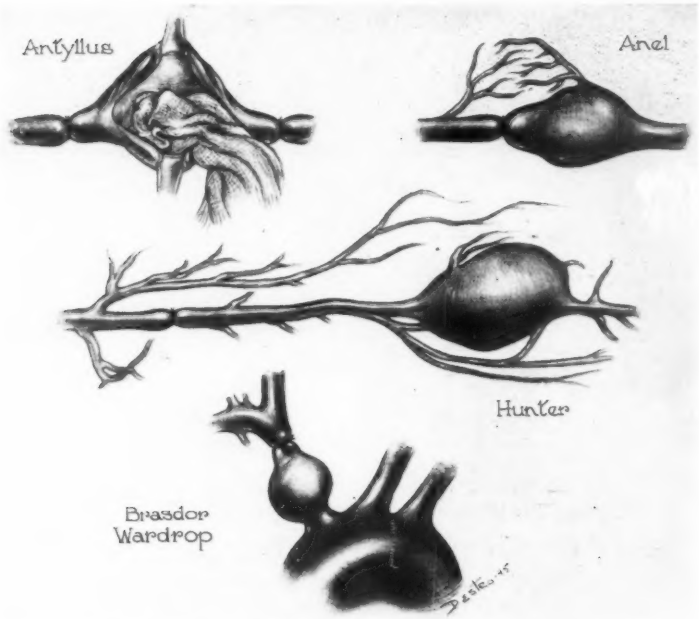


Fig. 2. Diagrammatic illustration of the types of operation employed for the treatment of aneurysms prior to the introduction of endoaneurysmorrhaphy.

crease in size until his transfer to Ashford General Hospital, August 13, 1944. At that time he was complaining of pain in the right thigh. On examination, there were numerous small well healed wounds in the left leg. On the upper anterior surface of the right thigh there was a large mass 15 by 30 centimeters. The mass was pulsating and over it a harsh systolic murmur could be heard (Fig. 6,a).

Since the mass was steadily increasing in size, an immediate operation was carried out. Through a small transverse incision just below Poupart's ligament, the common femoral artery was identified and temporarily occluded with an artery clamp. An incision 8 inches long was then made along the course of the femoral artery directly over the aneurysm (Fig. 6,b). The sac was opened and approximately 1200 cubic centimeters of clot was evacuated. Two openings in the femoral artery were closed with figure-of-eight sutures. The vessel was at the bottom of the sac which was bound by Hunter's canal posteriorly and the sartorius muscle anteriorly (Fig. 6,c). The clamp was released from the femoral artery and there was no further bleeding. The deep fascia and skin were closed with interrupted sutures of silk and a tight pressure bandage applied. His recovery was uneventful and the circulation in his foot and toes remained good.

CASE 3. False aneurysm, left superficial femoral artery, and false aneurysm, left profunda femoris artery, upper third, due to high explosive shell fragment wounds incurred August 29, 1944. Endoaneurysmorrhaphy, left femoral artery, upper third. Endoaneurysmorrhaphy, left profunda femoris artery, upper third, October 13, 1944. Recovery.

On August 29, 1944, this 32 year old soldier was struck by two shell fragments, both of which entered the anterior surface of the left thigh. The wounds were débrided and closed. About 5 days after injury, a swelling developed in the left anterior thigh region which was diagnosed as an aneurysm and he was evacuated to the United States. Shortly after reaching this country, swelling began to increase gradually, and he was admitted to Ashford General Hospital, October 11, 1944. At that time, he was complaining of pain in the leg and thigh. There was a massive spherical swelling on the anterior surface of the left thigh, about 10 centimeters below Poupart's ligament (Fig. 7,a). The mass pulsated with each heartbeat but there was no thrill. A distinct systolic bruit could be heard over it.

On October 13, 1944, operation was performed under spinal anesthesia. A small transverse incision was made over the femoral artery just below Poupart's ligament and a temporary, nonoccluding suture was passed around it. It was then occluded with a bulldog artery clamp. A longitudinal incision 6 inches long was made over the swelling, along the course of the femoral vessels (Fig. 7,b).

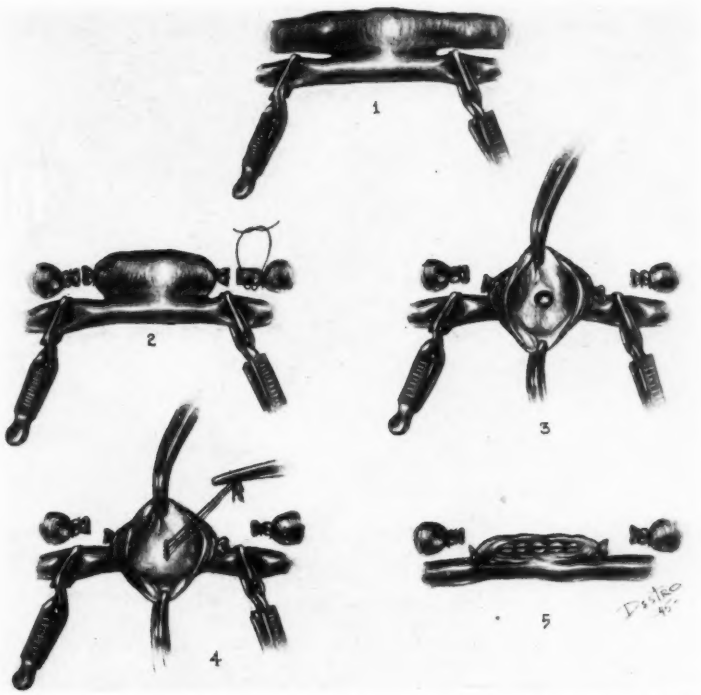


Fig. 3. Steps generally employed in the transvenous or transsaccular repair of an arteriovenous fistula with preservation of the artery.

The sac was opened and a clot, about 500 cubic centimeters, was evacuated. There was brisk bleeding from an opening in the femoral artery which was easily stopped by pressure with the fingers and was closed with several interrupted sutures of silk. The vessel just proximal and distal to this opening was dissected free from surrounding structures and again ligated.

Following this, the thigh still appeared tense and firm and, on this account, the fascia covering the adductor group of muscles was incised and another larger aneurysm disclosed. A clot of approximately 1,000 cubic centimeters was evacuated and an opening was found in the profunda femoris artery. This was closed with 4 interrupted sutures of silk. The sac was limited posteriorly by the adductor magnus muscle and laterally by the femur (Fig. 7,c). The deep fascia and skin were closed with interrupted sutures of silk, and a snug pressure bandage was applied. In spite of the ligation of the superficial femoral and profunda femoris arteries, circulation in his toes and foot was good at the end of the operation and remained so. The wound healed without difficulty.

Case 4. False aneurysm, right external iliac artery, due to bullet wound incurred June 27, 1944. Endoaneurysmorrhaphy and proximal ligation of the external iliac artery, September 16, 1944.

This officer received a through-and-through .30 caliber bullet wound of the abdomen June 27, 1944. The bullet entered the right lower quadrant anteriorly and made its exit just to the right of the 5th lumbar vertebra. Shortly thereafter he was operated upon and several perforations of the small intestine were repaired. His recovery from this operation was prompt except for superficial wound infection which soon healed. He was admitted to Ashford General Hospital August 28, 1944, complaining of pain in the right groin and throbbing in the right lower abdomen.

On examination there was a well healed lower right paramedian scar extending from the umbilicus to Poupart's ligament. Immediately above Poupart's ligament and underlying the scar was a mass approximately 6 centimeters in diameter. The mass was pulsating with each heart beat, and a systolic bruit could be heard over it. There was no thrill. The right dorsalis pedis and posterior tibial pulses could be felt, but both were weak in comparison to the other side. Oscillometric readings were diminished on the right.

Operation was performed September 16, 1944. The old scar which had been made for the closure of

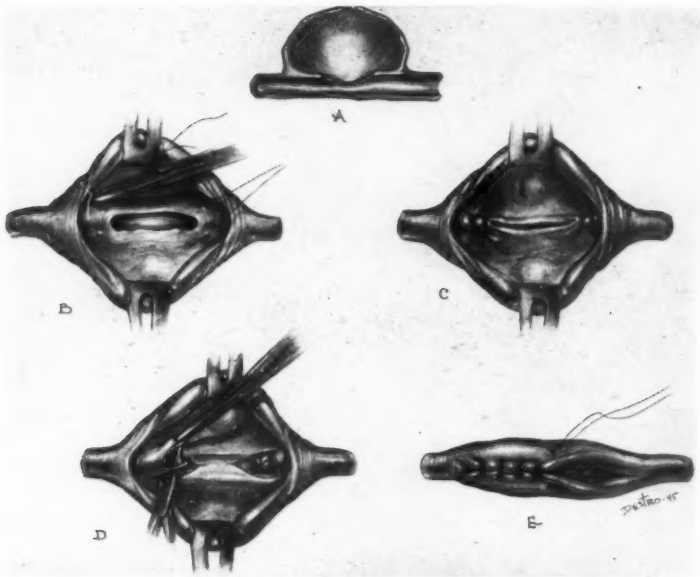


Fig. 4. Diagrammatic illustration of endoaneurysmorrhaphy. A, Cross section of artery with false sac. B, Sutures are placed to close the arterial openings within the sac. C, Sutures tied. D, Occasionally the vessel is isolated and ligated. E, Occasionally the sac is obliterated by further sutures.

intestinal perforation was excised. The peritoneum was dissected upward until the artery above the aneurysm could be reached. It was isolated and temporarily occluded with an artery clamp. The artery distal to the aneurysm was treated in a similar manner. The sac was opened and two arterial openings in it were closed with interrupted sutures of silk. On removal of the clamp, there was still some bleeding from the proximal opening which could be controlled only by ligation of the artery proximal to the aneurysm. No attempt was made to remove the sac (Fig. 8). The wound was closed in layers. Circulation in the foot and toes was good at the end of the operation and remained so. The patient's recovery was uneventful, and he was returned to duty of a limited nature.

TABLE I.—LOCATION AND NUMBER OF PATIENTS TREATED BY ENDOANEURYSMORRHAPHY

	Cases
Axillary	5
Brachial	14
Femoral	11
Iliac	2
Peroneal	1
Popliteal	7
Profunda femoris	3
Radial	4
Superior gluteal	1
Tibial, anterior	3
Tibial, posterior	8
Ulnar	2
Total	61

CASE 5. False aneurysm, right axillary artery, due to high explosive shell fragment wound incurred May 10, 1944. Endoaneurysmorrhaphy, June 25, 1944. Recovery.

This soldier was wounded on May 10, 1944. A small shell fragment entered his anterior chest just beneath the right clavicle and made its exit just below the scapula on the right side. Subsequently he developed a hemothorax which necessitated aspiration. At the time of his injury there was considerable bleeding from the wound in the anterior chest, which was controlled by pressure. Immediately following the wound he also noticed complete paralysis of the right upper extremity. About June 1, massage and active motion of the right shoulder was begun and shortly after this he noted the appearance of a swelling in the right axillary and subclavicular region. This swelling gradually increased in size until the time of his admission to Ashford General Hospital on June 16, 1944.

Examination at that time revealed a large firm mass which occupied an area beneath the right clavicle and extended into the axilla (Fig. 9,a). The mass was expansile and a definite systolic bruit

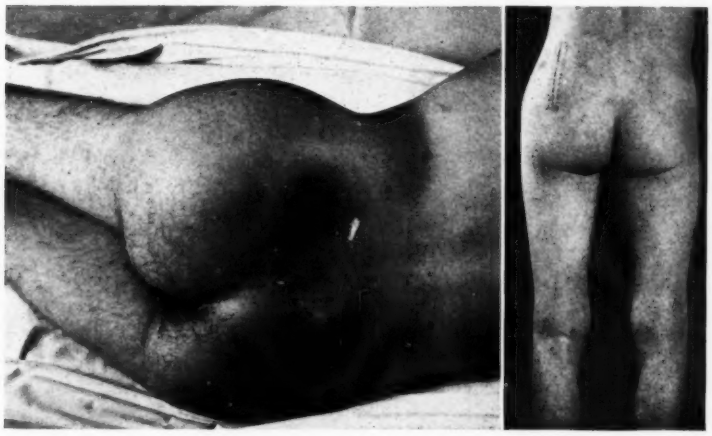
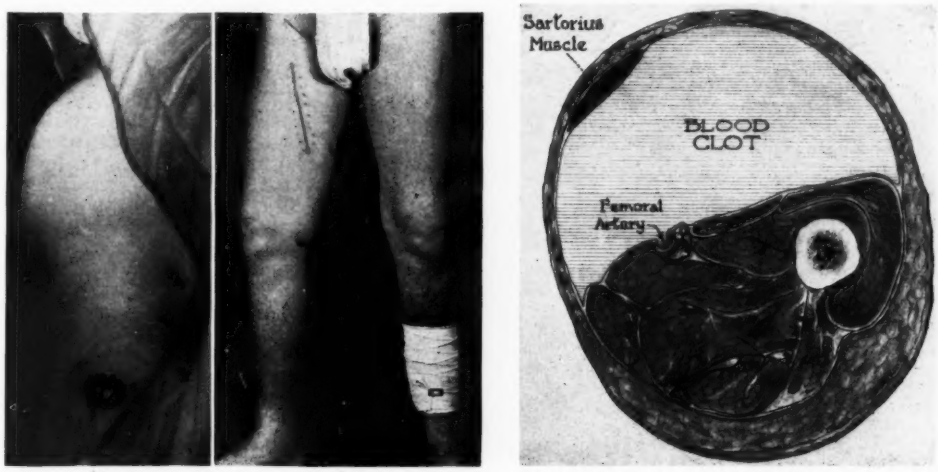


Fig. 5. Case 1. a, left. Preoperative photograph. Aneurysm of gluteal artery. b, Postoperative photograph showing incision.

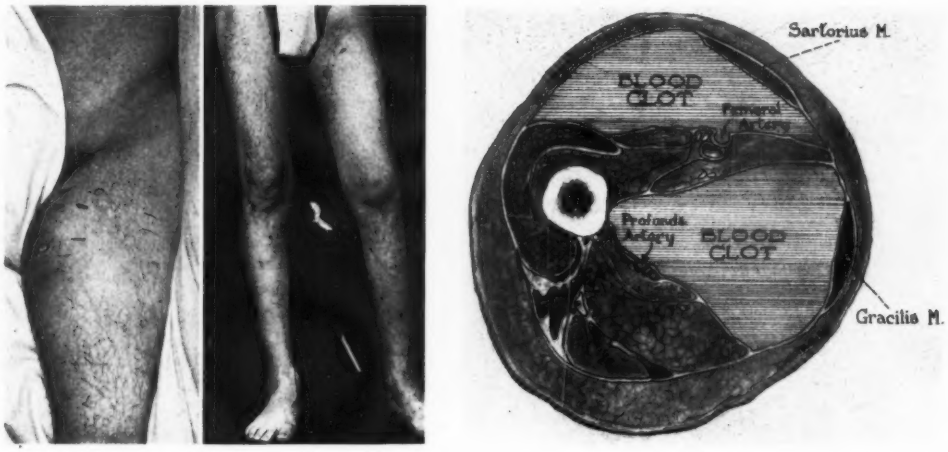
could be heard over it. There was evidence of extensive injury to the nerves of the right arm. Pulsation on the right radial artery was faint.

On June 25, 1944, because of a rapid increase in size of the aneurysm, operation was performed. An attempt was made to isolate the subclavian artery above the clavicle but it could not be reached because the clavicle was pushed upward by the aneurysm (Fig. 9,b). Since it was believed that the clavicle formed a part of the sac wall it was decided that it was best not to resect it in order to reach the subclavian artery (Fig. 9,c). An incision was therefore made across the axilla and the sac was exposed, opened, and approximately 2,000 cubic centimeters of blood and clot were evacuated. Bleeding was profuse but was controlled by finger pressure over two openings in the bottom of the sac. These openings were closed with interrupted sutures of silk. Because of the necrotic appearance of the sac and the large dead space which could not be obliterated, a



a b c

Fig. 6. Case 2. a, Preoperative photograph. Aneurysm of right femoral artery. b, Postoperative photograph showing incisions. The upper transverse incision was made for temporary occlusion of the femoral artery. c, Cross section illustration showing relative size and position of aneurysm.



a b c

Fig. 7. Case 3. a, Preoperative photograph. Double aneurysm of femoral and profunda femoris arteries. b, Postoperative photograph showing incisions. The upper transverse incision was made in order temporarily to occlude the common femoral artery. c, Cross section illustration showing relative size and position of aneurysms.

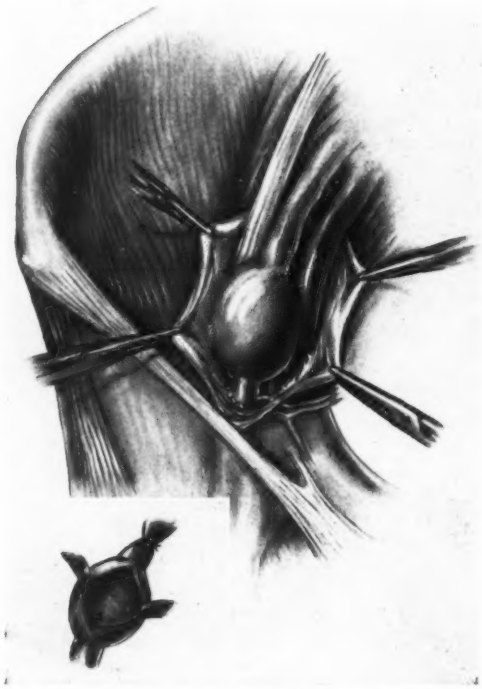


Fig. 8. Diagrammatic illustration showing operative procedure used in Case 4.

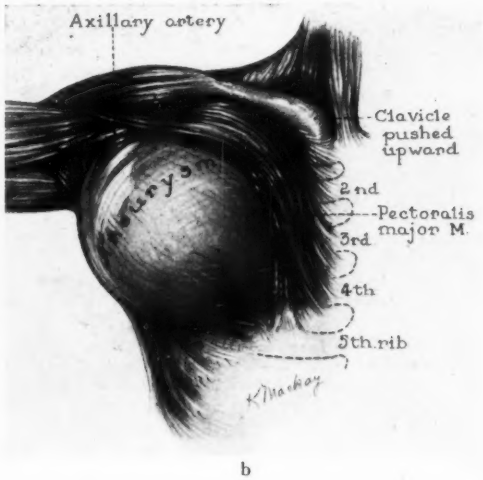
drain was left in the wound for 24 hours. His recovery was uneventful. The hand and fingers have remained warm. Two months later nerve repair of the radial, median, and ulnar nerves was done. At present there is evidence of returning nerve function.

CASE 6. False aneurysm, right brachial artery, due to mortar shell fragment wound incurred August 6, 1944. Endoaneurysmorrhaphy, right brachial artery, lower third, December 13, 1944. Recovery.

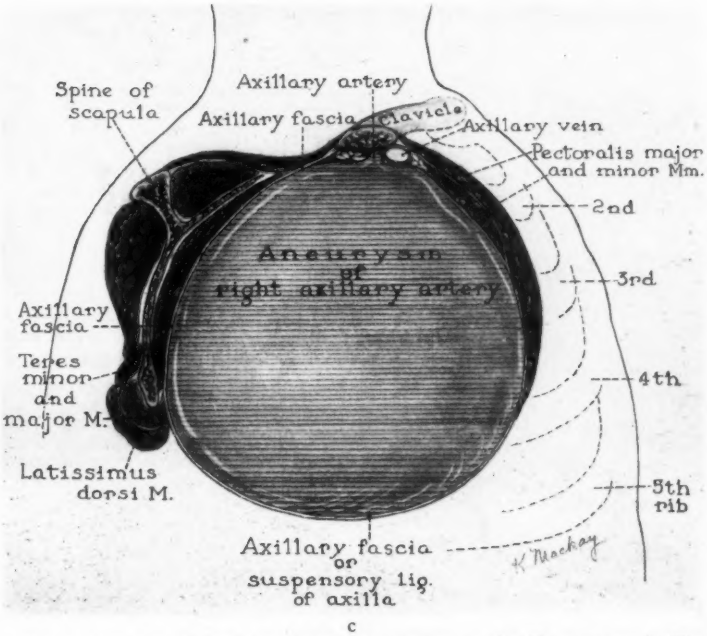
This 23 year old soldier was wounded by mortar shell fragment on August 6, 1944. The fragment entered the posterior surface of the forearm just below the elbow and caused a compound fracture of the ulna. Bleeding was slight and controlled by a pressure bandage. At the same time he sustained an injury to the median nerve which was partial and from which he gradually recovered. At an evacuation hospital in England the wound was débrided, a plaster splint applied, and he was returned to the United States. With the removal of the splint, an aneurysm was discovered just below the bend of the right elbow and for this he was admitted to Ashford General Hospital on December 5, 1944.

On admission he complained of pain and throbbing sensation in his right hand. Examination revealed a partial paralysis of the median nerve which was indicated by weakness of the muscles supplied by that nerve but which was said to be improving. Just distal to the right antecubital space was a fluctuant mass about 5 centimeters in diameter (Fig. 10,a). There was no thrill, but a systolic bruit could be heard over it. Skin temperatures of both hands were normal and symmetrical, although the right radial pulse was diminished in comparison with the left.

a



b



c

Fig. 9. Case 5. a, Preoperative photograph. Aneurysm of axillary artery. b, The approximate anatomic position of the aneurysm. c, Cross section showing relative size and position of aneurysm.

On December 13, 1944, operation was done under pentothal sodium anesthesia. A blood pressure cuff was used as a tourniquet on the arm. An incision 5 centimeters in length was made directly over the aneurysm and the sac uncovered (Fig. 10,b). A laminated clot, together with fresh clot, was evacuated. At the bottom of the sac the brachial artery was easily located. There were two openings in it 1

centimeter apart. Both were closed with interrupted sutures of silk. When the tourniquet was removed there was no abnormal bleeding. The deep fascia and skin were closed with interrupted sutures of silk. No attempt was made to obliterate the sac other than to apply a snug pressure bandage. Circulation in the hand and fingers was good at the end of the operation and remained so. Function of the median nerve returned without further operation.

CASE 7. False aneurysm, left radial artery, upper third, due to high explosive shell fragment wound incurred October 7, 1944. Endoaneurysmorrhaphy, June 16, 1945. Recovery.

This 23 year old soldier was wounded in action October 7, 1944. He suffered wounds of both upper extremities, the abdomen, and chest. He was operated upon within a few hours for perforations of the ileum and liver, from which he recovered without difficulty. After returning to the United States in May, the patient first noticed a pulsating tumor of the left forearm, and for this he was admitted to Ashford General Hospital on June 8, 1945. On examination there were noted numerous healed scars of both upper extremities, chest, and abdomen. On the lateral volar aspect of the left forearm there was a circumscribed pulsating tumor about 6 centimeters in diameter. Over this mass a systolic bruit could be heard. The skin temperatures of the fingers of both hands were normal and symmetrical. The left radial pulse was weak. There was no associated nerve injury (Fig. 11,a and b).

On June 16, 1945, operation was performed under pentothal sodium anesthesia. An inflated blood pressure cuff was used as a tourniquet on the arm. A longitudinal incision 5 centimeters long was made directly over the tumor mass which was easily uncovered. The sac was opened and some old and freshly organized clot was evacuated. The radial artery which was at the bottom of the sac had been partially divided producing an upper and lower opening each of which was closed with sutures of silk. The tourniquet was then removed and there was a slight oozing which was closed with another suture of silk. No attempt was made to obliterate the sac. The deep fascia and skin were closed with interrupted sutures of silk and a pressure bandage was applied from the fingers to the elbow. The circulation of the fingers was good at the end of the operation and remained so.

Fig. 12, a. Fig. 12, b.

(*Legend on following page.*)

CASE 8. Arteriovenous aneurysm, left external carotid artery and internal jugular vein with false venous sac, due to shell fragment wound incurred September 23, 1944. Paralysis of left recurrent laryngeal nerve. Ligation and division of right external carotid artery. Ligation and division of left

Fig. 10. Case 6. a, above, Preoperative photograph. Aneurysm of brachial artery. b, below, Postoperative photograph showing incision.

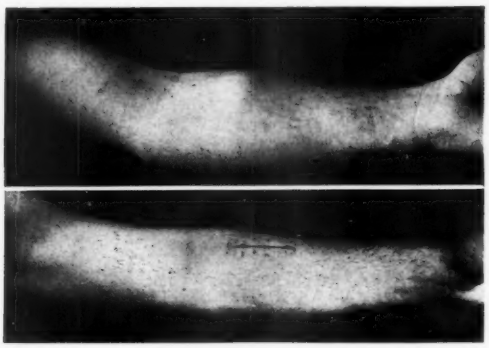


Fig. 11. Case 7. a, above, Preoperative photograph. Aneurysm of radial artery. b, below, Postoperative photograph showing incision.

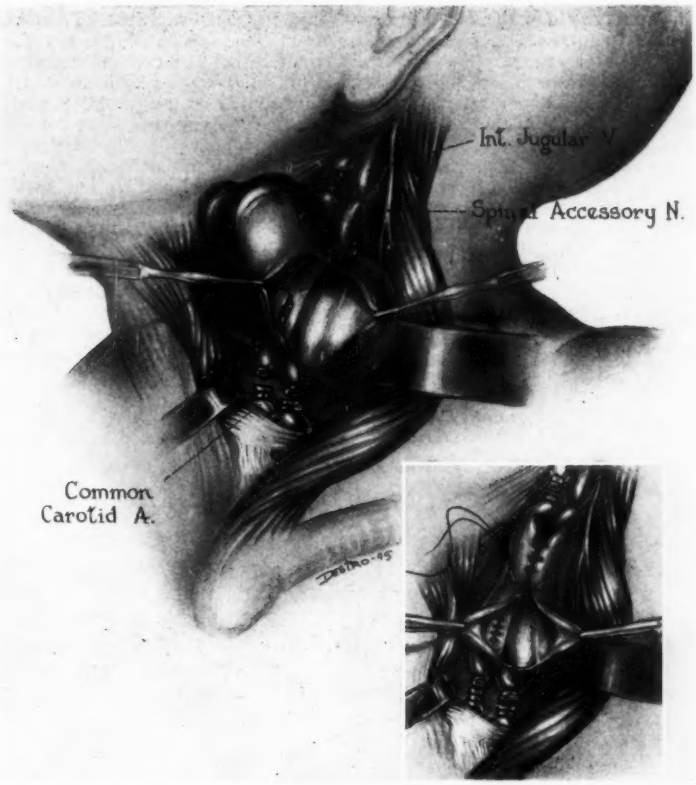


Fig. 12, c.

Fig. 12. Case 8. a, Preoperative photograph. Arteriovenous aneurysm of external carotid artery and internal jugular vein. b, Postoperative view showing incision. c, Repair by ligation and division of vessels and transsaccular closure of arterial openings.

common carotid artery and internal jugular vein. Ligation and division of distal arterial branches. Endoaneurysmorrhaphy. Recovery.

This 36 year old soldier was wounded in action by a mortar shell fragment which struck the infra-orbital region of his cheek. He was unconscious for approximately 10 days during which time a tracheotomy was performed because of respiratory difficulties. The tracheal tube was removed after 2 weeks. Soon after the injury a mass was noted in the left side of his neck and, on recovery of consciousness, he noticed that the left eyelid drooped and that he was hoarse. He was returned to the United States and admitted to Ashford General Hospital on December 19, 1944.

Examination revealed a small wound just below the left eye. Roentgenogram showed a foreign body in the left suprascapular region. There was definite Horner's syndrone on the left and paralysis of the left recurrent laryngeal nerve. In the left side of the neck extending from the ear almost to the clavicle was a mass of dilated vessels which was easily compressible (Fig. 12,a).

A harsh continuous bruit accentuated in systole could be heard over the mass and was transmitted to the scalp, down the left arm and to the left scapular region. A continuous thrill could be felt over the whole left side of the neck. The bruit and thrill were easily eliminated by compression of the common carotid artery. The mass in the neck became much less tense on obliteration of the artery and the pulse rate fell from 92 to 76 and the blood pressure changed from 110/70 to 110/84. Diagnosis of an arteriovenous fistula of the external carotid artery and internal jugular vein, together with false venous sac, was made.

Because it was apparent that considerable blood flow to this fistula came from both sides of the neck, preliminary ligation and division of the external carotid artery of the right side were done on Decem-

ber 28, 1944. On January 4, 1945, the final operation was carried out under pentothal sodium anesthesia. An incision was made along the anterior border of the sternomastoid muscle from the angle of the jaw to the sternum (Fig. 12,b) and the muscle was retracted laterally. This exposed a tense and dilated venous sac. The common carotid artery was ligated and divided which relieved this tenseness to some extent. By careful dissection about the sac and retraction laterally, three branches of the external carotid artery distal to the fistula could be ligated and divided. The internal jugular vein distal to the fistula was ligated. The internal jugular vein on the proximal side of the fistula was then ligated and divided. When this was done it became apparent that the fistula with the false sac could not be completely removed and therefore the sac was opened and the clot evacuated. There was some bleeding from three openings in the sac which were evidently branches of the external carotid artery. Bleeding from them was easily controlled by the passage of interrupted sutures of silk. A portion of the sac wall was excised and the remainder was imbricated over the previously closed arterial openings (Fig. 12,c). The deep fascia and skin were closed with interrupted sutures of silk. The operation required 6½ hours. The patient's condition throughout the operation was good and there was no difficulty in his breathing. Following the operation there was considerable difficulty in his breathing and swallowing but from this he recovered gradually within a period of a week. A month later he was discharged from the service with considerable improvement in his hoarseness but none in sympathetic paralysis.

WAR INJURIES OF THE CHEST

EARLE B. KAY, M.D., F.A.C.S., Major, M.C., A.U.S., and
RICHARD H. MEADE, Jr., M.D., F.A.C.S., Lt. Col., M.C., A.U.S.

AN ANALYSIS of a large series of cases having war injuries of the chest as observed in an Army Chest Center in this country seems desirable. Reports on the early phases of chest injuries have been published (1, 2). The present analysis represents a study in retrospect of the first 500 consecutive patients in 2350 such patients seen. The material for this study was obtained from a careful review of the patients' field medical records, records of previous hospitalizations, and serial roentgenograms as presented by the patients at the time of admission to a chest surgical center in the Zone of the Interior. The course of such chest injuries is viewed from the point of vantage of their last hospitalization. These cases were analyzed as to the character of the original injury, initial treatment, complications, and subsequent treatment. An evaluation of operative and conservative therapy is made. Closure of thoracotomy wounds with and without drainage is discussed in relation to postoperative morbidity. Other aspects of the treatment of war chest injuries have been thoroughly covered in previous papers and will not be repeated. Such an analysis as this is felt to be of value in the treatment of similar injuries in the future. The condition of the patients upon arrival in this country as well as the more important phases of late treatment is described.

The lowered mortality from chest wounds in this war has been due to their excellent primary care. Chemotherapy and penicillin have aided, but in themselves are no substitutes for sound surgical judgment. In some cases they may be detrimental to the patient's welfare if dependence on their protective ability leads the surgeon to take unnecessary risks.

Even though the mortality has been remarkably decreased from that in previous wars, the morbidity could be further reduced. Several factors have contributed to the present morbidity. Among the factors to be discussed are (1) the delayed or ineffectual aspiration of hemothoraces, (2) the tendency to close contaminated chest wounds primarily without drainage, (3) ill timed or unwise thoracotomy, and (4) the tight closure of sucking wounds of the chest in the face of underlying bronchopleural fistulas.

The early treatment of chest wounds should be concerned primarily with the correction of the altered cardiorespiratory mechanism contributing to the shock of the patient and with the prevention of infection. There are only a few chest conditions which require immediate surgical intervention. These are, large sucking wounds of the chest wall, tension pneumothorax, and uncontrollable bleeding. However, many emergency operations have been performed where these conditions have not existed. Many chest injuries fare better when they are treated by repeated, effectual, thoracenteses. The type of injury, as well as the nature of the offending agent, is of importance in the decision as to immediate thoracotomy.

Certainly in explosive injuries causing large sucking wounds, hemorrhage, and extensive laceration of the lung with retained spicules of rib, clothing, and metal, thoracotomy is indicated. However, these comprise only a small proportion of the injuries seen.

ANALYSIS OF THE INITIAL CHEST CONDITIONS

The causative agent in the majority of cases was either shrapnel or shell fragments. A minority of the injuries was due to bullets. Table I lists the types of the initial conditions in 500 patients.

Hemothorax or hemopneumothorax of some degree occurred in 455 of the 500 patients with chest injuries. It is interesting to note that 19 patients with either perforating or penetrating wounds of the chest escaped without devel-

From the Thoracic Surgery Section, Kennedy General Hospital, Memphis, Tennessee.

TABLE I.—ANALYSIS OF INITIAL CHEST CONDITIONS*

Condition	No. of cases
Hemothorax	455
Significant foreign bodies	211
Sucking wounds	136
Combined chest-abdominal wounds	75
Bronchopleural fistulas	45
Penetrating or perforating injuries only	19
Lung contusion	15
Pericarditis with effusion	10
Tension pneumothorax	9
Blast injuries	8
Hematoma of the lung	4
Fractured sternum	4
Injuries to the esophagus	3
Injuries to the trachea	2

*The occurrence of some of these injuries may have been higher but no reference was made to them in the records available.

TABLE II.—TREATMENT OF 455 PATIENTS WITH HEMOTHORAX

	Number of cases	Patients developing infection	
		No.	Percentage
I. Group treated by thoracentesis	225	38	16.8
a. Eliminating 11 patients with bronchopleural fistulas who became infected	214	27	12.6
b. Eliminating 13 patients inadequately tapped (1–2 aspirations) who became infected	212	25	11.8
c. Eliminating groups a and b	201	14	6.9
II. Group treated by operation	156	76	48.7
III. Group with no definite treatment	74	30	45.9
a. Eliminating 6 patients with bronchopleural fistulas who became infected	68	24	35.3
b. Eliminating 34 patients with small hemothoraces which healed spontaneously and 6 patients with bronchopleural fistulas	34	24	70.0

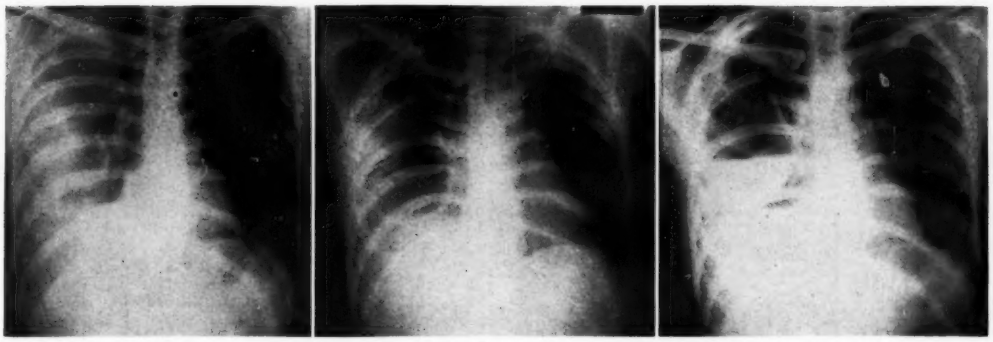
oping any detectable hemothorax. There were 211 retained foreign bodies. There were many more than this noted by roentgen examination but their size and location were such as not to be of clinical significance. One hundred and thirty-six sucking wounds of the chest wall were of such a degree as to require immediate closure. There were 62 extensive lacerations of the lung and 45 clinically significant bronchopleural fistulas. Transitory fistulas must have been present in other cases but apparently were not complicating factors. There were 75 combined chest-abdominal injuries. In several instances multiple abdominal organs were involved. The organs injured in the order of incidence were liver, 40; spleen, 16; stomach, 15; kidney, 9; small intestine and colon, 7. The other initial injuries are self explanatory as noted in Table I.

The good results being obtained in patients with war chest injuries are due to the excellent organization providing the best care from the onset by the medical corps men and front line surgeons. The immediate use of morphine, tetanus toxoid, plasma, transfusions, sulfonamides, penicillin, and followed when indicated by prompt débridement, thoracentesis, and exploratory thoracotomy have saved many lives that would otherwise have been lost.

Four hundred and fifty-five patients had some degree of hemothorax, many of which were associated with other conditions such as sucking wounds, lacerated lung tissue and retained foreign bodies. Others were uncomplicated. In a number it was impossible to determine the condition of the intrathoracic organs prior to operation.

The most severely injured patients had thoracotomies. In other instances, patients with less severe injuries were also operated upon. In a comparative analysis in retrospect from material obtained from the field medical records and serial roentgenograms, it is difficult properly to evaluate all of the factors confronting the attending surgeon and influencing his decisions as to the type of therapy employed. In discussing results obtained in the treatment of hemothorax by various methods, hemothorax alone will be considered apart from the accompanying conditions. As may be noted in Table II, 225 of the 455 patients with hemothorax were treated conservatively by thoracenteses, 156 had thoracotomies, and 74 had no definite treatment.

Results obtained with and without thoracentesis. The effectiveness of adequate repeated thoracenteses in the treatment of hemothorax is emphasized by the data in Table II. It is important to note that only 16.8 per cent of hemothoraces aspirated became infected, in comparison to 45.9 per cent of those not aspirated. The difference in the results obtained is even more striking if patients with bronchopleural fistulas and inadequate thora-



a b c

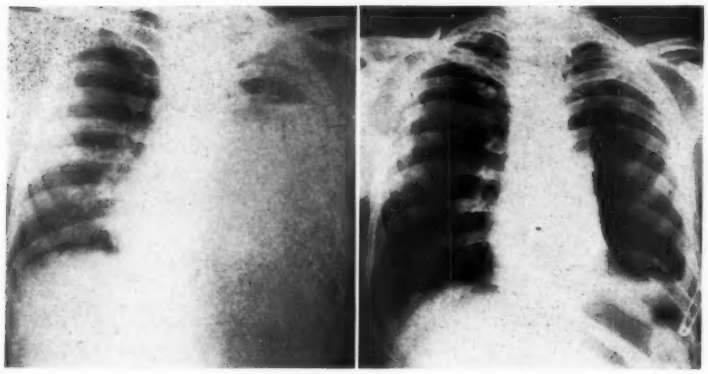
Fig. 1. a, A hemothorax secondary to a perforating wound of the right chest. b, The chest 2 days following thoracotomy and hemostasis. No thoracotomy drainage was employed because the amount of contamination was thought to be minimal. c, A fluid level in the right hemithorax indicative of a postoperative empyema.

centeses (only 1 to 2 aspirations) are eliminated from the first group. An incidence of infection of 6.9 per cent results in patients adequately treated. This may be compared to the second group, in which thoracentesis was not used. If 6 patients with bronchopleural fistulas are eliminated and 34 patients with only small collections of blood in the pleural space are not considered, an incidence of infection of 70 per cent results.

Operative versus conservative therapy in initial chest injury. Considerable advance has been made in thoracic surgery since the last war. The lowered mortality from chest wounds is in part due to the ability of present day surgeons to cope successfully with intrathoracic operations. However, as previously stated, there are only certain indications for immediate thoracotomy. The presence of a penetrating or perforating wound of the chest in itself is not an indication. Many operations designed to stop hemorrhage or to prevent infection have instead been followed by these as complications (Fig. 1). This is particularly apt to be true if the chest is closed without drainage.

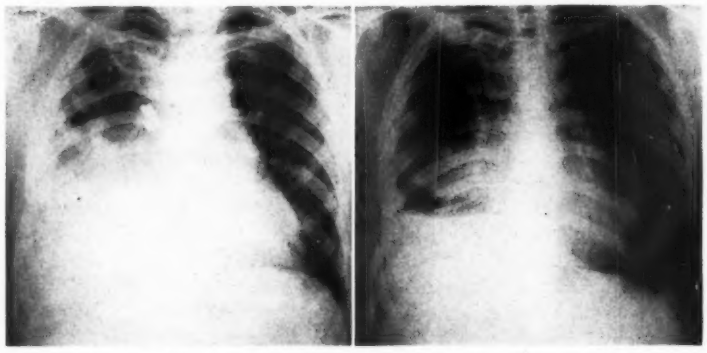
One hundred fifty-six patients had initial thoracotomy, débridement, hemostasis, and repair of the injured tissues within the first 24 to 48 hours. Of these 156 cases, 48.7 per cent were complicated by an infected hemothorax (Table II), 30 per cent by hemothorax relieved by thoracenteses, and 6 per cent by organized hemothorax. According to these figures, the operative group fared much worse than the group followed conservatively with thoracenteses, in which only 16.8 per cent of the patients required additional treatment. It is realized that the operative group included the severe injuries in which operative therapy was mandatory and the likelihood of complications great if operation had not been done, but it also included patients who would have done as well or better on conservative therapy alone. Of the 156 patients having early thoracotomies, in 66 no obvious indication for immediate operation could be found in their field medical records. The majority of these had retained foreign bodies in addition to a hemothorax. Sixteen patients were found at the time of operation to have lacerated lung tissue. A number of these patients had their wounds closed without drainage and did not receive adequate postoperative thoracenteses. Many of these patients developed infection which required drainage (Fig. 2). No mention is made of chemotherapy (sulfonamides and penicillin) for this was employed in all groups.

Comparison of results obtained in patients having thoracotomies closed with drainage and without drainage. There were 189 patients in all who had thoracotomies prior to arrival in this country. This includes 33 patients who were operated upon at a later date in addition to the initial 156. In 81 patients wounds were closed with drainage and in 108 without. In



a b

Fig. 2. Roentgenograms illustrating a penetrating bullet wound of the left chest. The bullet is noted in the left apex. An immediate thoracotomy was performed for hemostasis and to remove the bullet. The bullet was so located in the mediastinum as to prevent its removal. The chest was closed without drainage. a, A postoperative hemothorax. This later became infected and was treated by open thoracotomy drainage. b, The resulting total empyema space.



a b

Fig. 3. Roentgenograms illustrating a penetrating wound of the right chest resulting in a retained shell fragment and a hemothorax. a, Condition of chest prior to operation. b, A postoperative pneumothorax secondary to a bronchopleural fistula. The wound was closed without drainage and an empyema resulted that required drainage on three occasions.

those closed with drainage 82.7 per cent healed without requiring secondary operations in contrast to only 43.5 per cent of those closed without drainage.

The patients who were drained and yet became infected had the most severe injuries. There was an average length of healing in the first group of 10 weeks as compared to 14 weeks in the second group. Even though 43.5 per cent of the patients closed without drainage healed primarily, the higher incidence of postoperative infection requiring secondary operations and the longer period of convalescence in those who became infected makes this type of treatment less desirable than the use of postoperative drainage.

Conditions under which a surgeon must care for the wounded at the battlefront do not always allow him to supervise the postoperative care for a sufficiently long period of

TABLE III.—THORACOTOMIES CLOSED WITH AND WITHOUT DRAINAGE

	Closed with drainage	Closed without drainage
Number of cases	81	108
Percentage healing without secondary operations	82.7	43.5
Percentage requiring secondary operations	17.3	56.5
Average duration of healing	10 weeks	14 weeks

time, nor allow the thorough aspirations of a hemothorax before the patient must be evacuated elsewhere. It seems far safer, therefore, to employ routinely water seal drainage after thoracotomies. This would be followed by less risk to life and lowered morbidity, and would require considerably less of the surgeon's time and attention than would repeated postoperative thoracenteses. During transportation the thoracotomy tube could be clamped and the bottle temporarily disconnected, or a flapper type drain used.

Foreign bodies. Of the original 211 retained foreign bodies, 47 were removed at the time of the original operation and 33 after an interval of several weeks. In many patients the foreign body was removed incidental to débridement, hemostasis, and repair of lacerated lung tissue, while in others the operation was designed primarily for the removal of the foreign body. In this latter group the chest was frequently closed without drainage because the extent of injury was not great. In the process of removing the foreign body, bronchopleural fistulas frequently were created, and these were not adequately repaired, as demonstrated in Figure 3. The incidence of postoperative infection in this group alone was 30 per cent.

There is considerable difference of opinion as to the clinical significance of metallic foreign bodies and the indications for their removal. The chief reason for removing pulmonary foreign bodies is the possible development of hemorrhage or infection. Of the entire group only 8 were later associated with hemoptysis, 7 with lung abscesses, 6 with pneumonitis, and 8 with draining sinuses. These conditions occurred for the most part within 2 to 4 weeks following injury. Those foreign bodies associated with infection were usually found at operation to be intermingled with other débris such as particles of clothing and dirt which probably was the cause of the infection rather than the metallic foreign body itself. Only experience over a longer period of time will enable the surgeon to evaluate the late results of residual foreign bodies and the advisability of their removal.

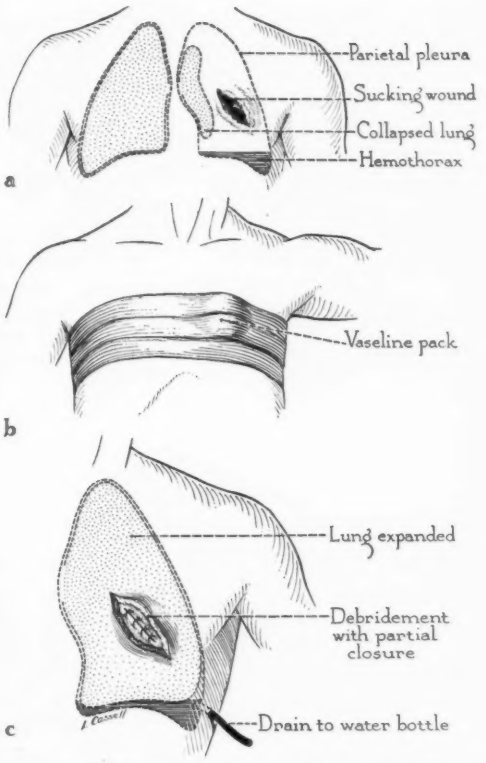
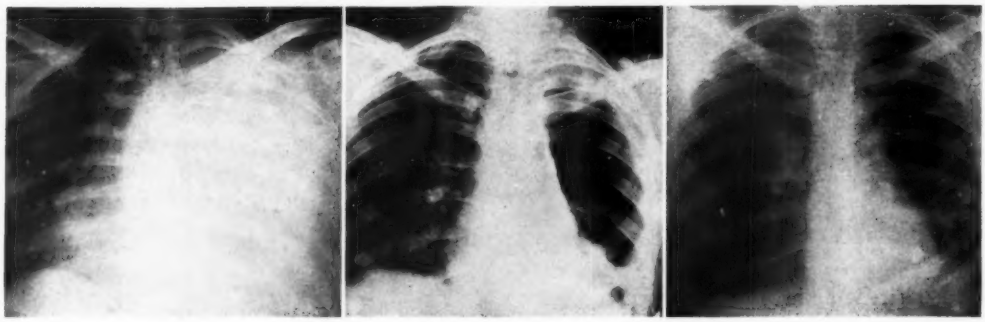


Fig. 4. Diagrammatic illustration of the emergency treatment, b, by packing with vaseline gauze and tight application of adhesive tape to sucking wound illustrated in a. c, Diagrammatic demonstration of the definitive treatment of sucking wounds of the chest wall by débridement and partial closure including the pleura and muscle layer but leaving subcutaneous adipose tissue and skin open. An intercostal water seal thoractomy tube is inserted to drain the inevitable hemothorax.

SUCKING WOUNDS OF THE CHEST WALL

There were many more sucking wounds of the chest wall than the 136 listed, but these were small enough to be of no clinical significance and responded promptly to either packing, or débridement and primary closure.



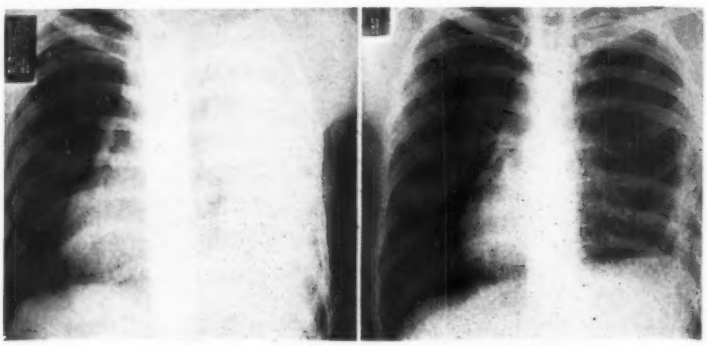
a b c

Fig. 5. Serial roentgenograms. a, An early infected hemothorax with mediastinal shift to the opposite side. b, A total residual empyema space following early open thoracotomy drainage. c, The appearance of the healed chest following continuous suction therapy over a period of 4 months.

There was between 5 to 10 per cent infection in such wounds closed primarily. In several instances tension pneumothorax developed after closure of the sucking wound when underlying bronchopleural fistulas were not recognized. In the larger sucking wounds of the chest wall, emergency closure by packing was followed almost universally by débridement and primary closure. Fifty-seven per cent had thoracotomies in addition to closure of the sucking wounds. Several patients with sucking wounds had only partial closure of the chest wall following débridement in conjunction with intercostal water seal drainage as demonstrated in Figure 4. The convalescence of these patients was the least complicated of all.

INJURIES TO THE ESOPHAGUS AND TRACHEA

There were 3 injuries to the cervical esophagus and 2 to the upper end of the trachea in the first 500 patients analyzed. Eight additional cases have since been seen. No injury to the thoracic esophagus was noted even though, in a number of instances, ragged shell fragments have lodged in the posterior mediastinum close to the esophagus (Fig. 8,d). The high mortality resulting from mediastinitis and hemorrhage associated with such injuries accounts for the few patients seen in the Zone of the Interior. Three patients had immediate tracheotomies and 4 patients gastrostomies within 4 to 10 days' time. All of these injuries were complicated by esophageal fistulas and abscesses requiring drainage.



a b

Fig. 6. Roentgenograms demonstrating, a, an infected organized hemothorax and b, the postoperative result following decortication.

TABLE IV.—COMPLICATIONS (CHEST)

Complications	No.
Infected hemothorax	144
Hemothorax	47
Organized hemothorax	49
Bronchopleural fistula	36
Subphrenic abscess	12
Pneumonitis and lung abscess about foreign body	11
Tension pneumothorax	9
Pneumonitis and abscess at site of hematoma	4
Infected costal cartilage	7
Atelectasis	9
Pulmonary infarct	3
Bronchopneumonia	5
Hemoptysis secondary to foreign body	8
Pericarditis with effusion	8
Suppurative pericarditis	2
Pericardial tamponade	2
Esophageal fistula with paraesophageal abscess	3
Diaphragmatic hernia	5

Two patients developed esophageal strictures requiring dilatation. The tracheotomy tubes were removed within 3 to 4 weeks with no further difficulty in breathing. Four of the 6 patients also had recurrent laryngeal nerve paralysis that persisted. The eventual outcome in these 6 patients was satisfactory.

COMBINED CHEST-ABDOMINAL INJURIES

The majority of the chest-abdominal injuries were successfully treated through a transthoracic approach. Others were explored through the abdomen. In case of doubt as to the extent and location of the abdominal injury, the abdominal approach allows better exploration. The diagnosis of a concomitant abdominal injury is frequently difficult to make, for diaphragmatic and intercostal irritation frequently give abdominal pain, tenderness, and muscle spasm. In combined injuries the abdomen deserves primary attention if the chest is stable. Only when large sucking wounds of the chest wall, tension pneumothorax, pericardial tamponade, or rapidly developing hemothorax associated with shock not relieved by conservative therapy are present should the chest condition be given first consideration. Intratracheal anesthesia should be employed in all operations for combined chest-abdominal injuries regardless of approach, for if there is a tear of the diaphragm, atmospheric air from the abdominal incision may cause collapse of the lung on the affected side and even tension pneumothorax. When injuries to the liver are explored transpleurally, both the subphrenic and pleural space should be drained. When this precaution is not taken bile empyema and subphrenic abscess are frequent developments. Bile empyema occurred in 14 instances. The most significant ones followed closure of the wound without drainage.

Fig. 7. Roentgenogram demonstrating lipiodol visualization of bronchopleural fistula, narrow empyema tract, and drainage site some distance from fistula.

The liver appears to tolerate the presence of metallic foreign bodies very well. Liver abscess secondary to a metallic foreign body was not noted in this series, even though biliary drainage was present following injury in a number of patients. In injuries to the lower chest, careful urinalysis for the presence of blood is indicated. Intravenous pyelograms have occasionally illustrated defects in the renal pelves secondary to such injuries.

Complications—chest. Infected hemothorax was the largest single complication. Fifty-three per cent of 144 cases were secondary to thoracotomies. Many of the thoracotomy wounds were closed without drainage and because of the necessity of evacuation to other hospitals, thoracenteses were often delayed or infrequent. Forty-seven patients developed postoperative hemothorax. All of this group responded favorably with repeated aspirations. Forty-nine patients developed organized hemothorax. Twenty of these had had only one aspiration or none at all and 7 had only two aspirations; 9 followed previous thoracotomies.

The majority of the 36 bronchopleural fistulas were secondary to severe injuries; 8 were secondary to removal of foreign bodies; and 6 were noted only after the development of

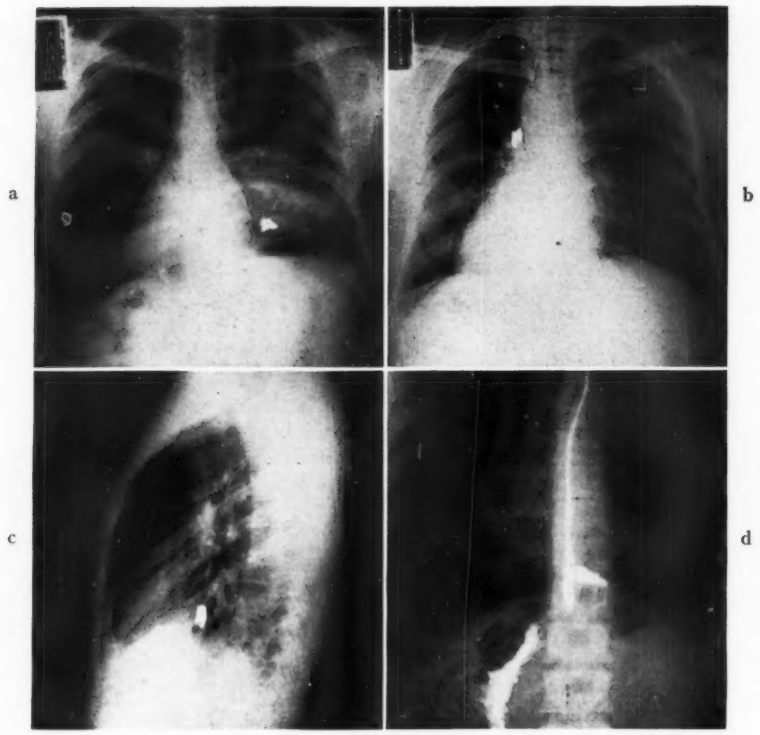


Fig. 8. Roentgenograms demonstrating, a, a foreign body associated with pneumonitis and fibrosis. b and c, foreign bodies in contact with large blood vessels, and d, a foreign body in contact with the esophagus.

empyema. Eleven patients had roentgen evidence of either pneumonitis or lung abscess at the site of foreign bodies. In 4 patients pulmonary hematomas became infected, liquefied, and required drainage. The other complications are self-explanatory as noted in Table IV. The surgical treatment of the complications is tabulated in Table V as follows:

TABLE V.—TREATMENT OF COMPLICATIONS

Treatment	No. of cases
Thoracenteses	47
Drainage empyema	151
Redrainage empyema	46
Decorticat on	49
Closure bronchopleural fistulas	9
Drainage subphrenic abscess	12
Repair of diaphragmatic hernia	5
Drainage lung abscess	3
Pericardial aspirations	11
Drainage suppurative pericarditis	2
Drainage pericardial tamponade	1
Resection of osteochondritis	4

EMPYEMA

Etiology of empyema. One hundred fifty-one patients developed empyema secondary to the chest injury. In some, several factors appeared to contribute, such as bronchopleural fistula, or extensive injury with considerable contamination in patients whose wounds were closed without drainage following operation. In 41.2 per cent the cause was directly concerned with some aspect of the injury such as its severity, extensive contamination, or laceration of the lung with bronchopleural fistulas. In 58.8 per cent failure to provide adequate aspiration of a hemothorax in the nonoperative cases, or postoperative water seal drainage in the operative group, was responsible, either wholly or in part, for the development of the empyema. Of this 58.8 per cent, 31.4 per cent had thoracotomies

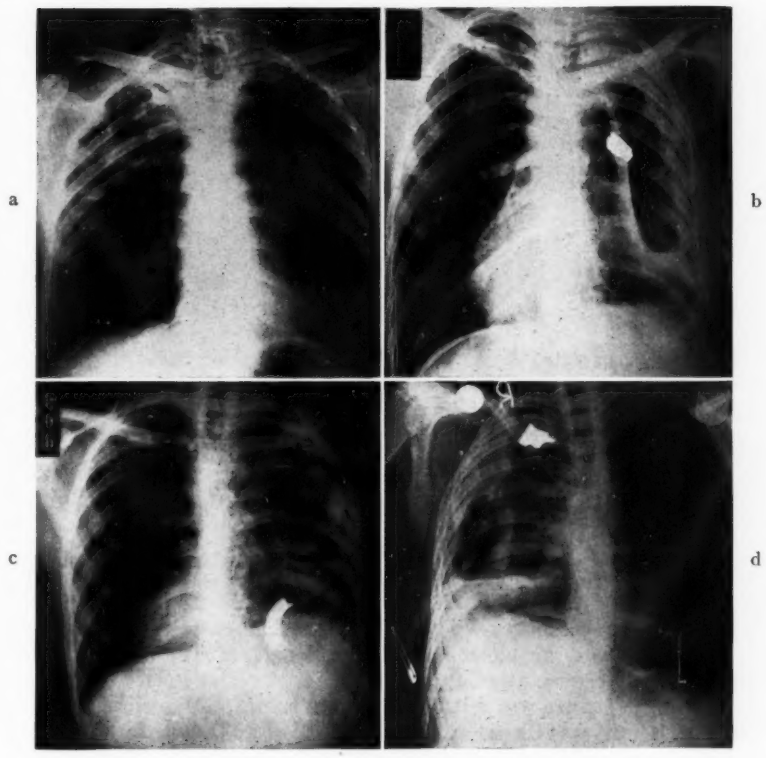


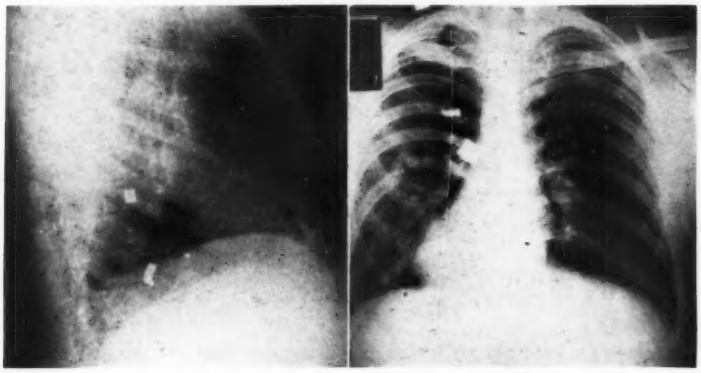
Fig. 9. Roentgenograms demonstrating, a, a lung abscess associated with a metallic foreign body. At time of operation clothing and other débris were found in the abscess cavity. b, A large foreign body partially embedded in the lung parenchyma and protruding into the empyema cavity. c and d, Large foreign bodies in the lung parenchyma associated with empyemas.

without postoperative drainage, 9.4 per cent too early removal of the thoracotomy tube, and 18 per cent inadequate thoracenteses (0–2 aspirations). No patient operated upon developed an empyema of clinical significance as a result of water seal drainage. This analysis suggests that the incidence of empyema could have been appreciably reduced if adequate water seal drainage had been provided. The average interval prior to drainage of the empyema was 3½ weeks.

Condition on admission to chest surgical center. Certain aspects of value in the late treatment of these conditions will be discussed. The majority of the chronic empyemas are adequately drained and in a state of healing when admitted. Those that are not adequately drained are redrained. Most are either small or moderate in size. During the early phases of the war there was a tendency to perform early open thoracotomy for infected hemothorax. Total empyema spaces were a fre-

TABLE VI.—CONDITION ON ADMISSION TO CHEST SURGICAL CENTER

Condition	No. of cases	Percentage
Healed	314	62.8
Chronic empyema	82	16.4
Fore gn bodies	49	9.8
Bronchopleural fistula	36	7.2
Draining sinus	26	5.2
Organized hemothorax	12	2.4
Hemothorax	9	1.8
Diaphragmatic hernia	4	0.8
Esophageal fistulas and paraesophageal abscess	3	0.6
Pericardial effusion	2	0.4



a b

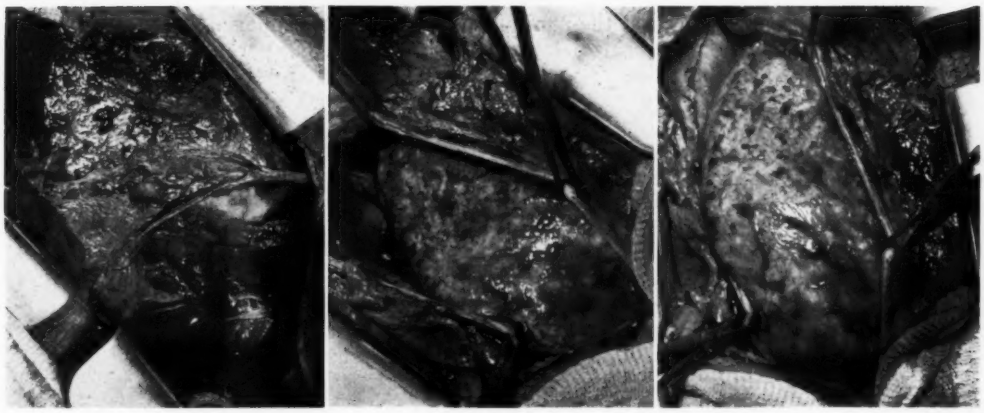
Fig. 10. Roentgenograms demonstrating, a, metallic foreign bodies causing hemorrhage 1 year following injury and, b, a metallic foreign body causing intercostal pain.

quent aftermath of this form of treatment (Fig. 5). This method of treatment has been almost entirely stopped. Such patients when received were placed on continuous suction employing from 30 to 50 centimeters of negative pressure. Breathing exercises, blow bottles, and dakinization were also employed as were high vitamin diets, supplementary vitamins, repeated transfusions, plasma, and a general hygienic regimen. It was felt that re-expansion of the lung was more apt to occur, and at a faster rate when suction was employed. Later it was found that empyema secondary to hemothorax can be treated by decortication with almost the same degree of success as an organized hemothorax without infection (Fig. 6). With the type of treatment described, only the rare empyema finally requires thoracoplastic closure.

As is noted in Table VI, 36 patients had bronchopleural fistulas on admission to the hospital. Such cases are investigated roentgenologically by the introduction of iodized oil to determine the size of the residual empyema space and the anatomical relationship of the bronchopleural fistula to the site of thoracotomy drainage. If the fistula is demonstrated to be at some distance from the cutaneous wound and drained by a long narrow empyematous tract (Fig. 7), it has been found that the establishment of drainage directly over the fistula promotes more rapid healing.

At the time of redrainage, exploration of such fistulas has often shown necrotic spicules of ribs, pieces of clothing, and other foreign material embedded in the lung preventing healing. Their removal and the excision of the scar tissue about the bronchopleural fistula has usually been promptly followed by healing. Occasionally muscle flap closure of the fistula must be resorted to if the steps enumerated do not suffice.

One hundred and thirty-one patients were admitted with roentgen evidence of metallic foreign bodies, but only 49 were felt to be of such a size, or so located as to be of clinical significance. Rarely is there evidence of infection either roentgenologically or surgically in the lung fields when metallic foreign bodies alone are present. Of the 49 with significant foreign bodies in the first 500 patients, in only 23 was there felt to be sufficient justification for their removal. If a foreign body persists for several months without giving any signs or symptoms, the likelihood of subsequent trouble is probably remote. Decision for removal of foreign bodies at this center depends on their size, location, and the presence of signs or symptoms. Large ragged shell fragments within the lung parenchyma and especially if associated with pneumonitis or fibrosis, or in the mediastinum in contact with the esophagus or large blood vessels as noted in Figure 8 are removed. Foreign bodies associated with a lung abscess or an empyema are re-



a b c

Fig. 11. Photographic illustrations of a decortication. a, An organized hemothorax after evacuation of the fibrinous mass from the pleural space showing the organized fibrin on visceral pleura. b, Easily obtainable cleavage plane between fibrous encasement and visceral pleura. c, Re-expansion of lung with positive pressure anesthesia.

moved if readily obtainable at the time of drainage (Fig. 9). If not, then they are removed at a later date if causing a drainage sinus. Foreign bodies causing hemoptysis or intercostal pain are removed if it can be shown that the foreign body is directly responsible (Fig. 10).

Only occasionally the psychological factors of fear and pain are such as to indicate the removal of a foreign body that would not otherwise be removed. Foreign bodies when unaccompanied by other débris have been found at operation to be associated with surprisingly little reaction and no infection. Those in contact with large blood vessels have been well encapsulated in fibrous tissue. Because of these observations, the tendency has been to remove fewer and fewer foreign bodies and then only when indicated. Tetanus toxoid is always given preoperatively as well as penicillin which is also continued for 4 to 5 days postoperatively. At the time of admission to this center 4 patients still had either pneumonitis or lung abscesses, 3 had hemoptysis, and 4 had draining sinuses. The onset in most of these was shortly after injury. No evidence of infection has as yet been seen to develop in those patients having retained foreign bodies shown roentgenologically to be free of infection for as long as 2 to 3 months. Two patients had gross hemoptysis 6 months to a year after injury.

Decortication in cases of organized hemothorax has enjoyed considerable popularity and is indeed responsible for the amazing results obtained in many individuals who would otherwise have suffered from a chronic fibrothorax. In 8 per cent of the hemothorax patients, clotting of the blood occurred to the extent of preventing evacuation of the blood by aspiration. In neglected cases the lung is compressed against the mediastinum by an encasement of organized fibrin which prevents the lung from re-expanding, immobilizes the diaphragm, and lines the parietal surface. This layer of fibrin in some instances may be 1.5 centimeters in thickness. The pleural cavity usually contains a jelly-like fibrinous mass. The operation of decortication as shown (Fig. 11) consists of developing an easily obtainable cleavage plane between the fibrous encasement and the adjacent visceral pleura, pericardium, diaphragm and chest wall from which it can be easily separated allowing re-expansion of the lung. When this layer is first incised as shown in Fig. 11,b the line of incision quickly gaps and lung tissue herniates through the opening. The best results are those done early (4 to 6 weeks). After the lung has been allowed to remain collapsed for

3 months or more, some fibrosis of the parenchyma frequently takes place causing delayed postoperative re-expansion.

SUMMARY

An analysis of 500 consecutive patients with war injuries of the chest is presented. The course of these injuries is viewed from the point of vantage of their last hospitalization. The material for the study was obtained from a careful review of the patients' field medical records, records of previous hospitalizations, and serial roentgenograms as presented by the patients at the time of admission to a chest surgical center in the Zone of the Interior. The character of the original injury, initial treatment and complications are described. An evaluation of operative and conservative therapy of chest injuries is made.

Closure of thoracotomy wounds with and without drainage is discussed in relation to postoperative morbidity. The condition of the patients upon arrival in this country as well as the more important phases of late treatment is described.

The effectiveness of repeated thoracentesis in the treatment of 225 patients with hemothorax is apparent in the incidence of infection of only 16.8 per cent as compared to an incidence of infection of 45.9 per cent in 74 patients not aspirated.

Early thoracotomies employed in the treatment of chest injuries designed to stop hemorrhage or to prevent infection have frequently been followed by these as complications. This is particularly apt to be true if the chest is closed without drainage. Of the 156 initial thoracotomies, 48.7 per cent were complicated by an infected hemothorax, 30 per cent by a hemothorax, and 6 per cent by an organized hemothorax. The operative group includes the more severe injuries and the likelihood of complications is greater, but it also includes a number of patients that could have been treated as well by conservative means.

The advantage of postoperative water seal drainage over primary closure of thoracotomy operations without providing drainage is demonstrated by an incidence of healing without requiring secondary operations of 82.7 per cent in patients drained in contrast to only 43.5 per cent in those not drained. Conditions under which a surgeon must care for the wounded at the battle front does not always allow time to supervise the postoperative care for a sufficiently long period of time, nor allow the thorough aspirations of a hemothorax before the patient must be evacuated elsewhere. It seems far safer, therefore, to employ water seal drainage routinely after such thoracotomies.

The treatment of foreign bodies, sucking wounds of the chest wall, injuries to the esophagus and trachea, as well as combined chest-abdominal injuries is discussed.

The late treatment of chronic empyema, bronchopleural fistulas, intrathoracic foreign bodies, and organized hemothorax is described.

REFERENCES

1. D'Abreu, A. L., Litchfield, V. W., and Hodson, C. J. Lancet, Lond., 1944, 2: 197.
2. Nicholson, W. F., and Scadding, J. G. Lancet, Lond., 1944, 1: 299.

INTRAVENOUS GELATIN FOR NUTRITIONAL PURPOSES

Clinical and Experimental Studies

ALEXANDER BRUNSCHWIG, M.D., F.A.C.S., SABRA NICHOLS, S.B., and ROBERT BIGELOW, M.D., Chicago, Illinois

GELATIN is an incomplete protein since it does not include all the amino acids essential for normal growth and reproduction. Recently, certain gelatins have been employed in the treatment of shock as a plasma or "blood substitute." The following report is concerned with animal experiments and clinical studies employing gelatin as a parenteral nitrogenous nutriment.

The gelatin employed has been previously described.[1] It was prepared from pigskin, autoclaved several times and made up into an 8 per cent solution in normal saline.

As the purpose of this study was to determine whether intravenous gelatin is utilized for synthesis of the organism's own proteins (plasma proteins in particular), certain control studies were necessary. Since gelatin is a colloid, the first step was to observe the effects of repeated intravenous injections of an inert non-nitrogenous colloid. Gum acacia, 6 per cent in saline was injected daily intravenously in 2 dogs weighing 7.7 and 7.1 kilograms, respectively. The quantities injected varied from 200 to 400 cubic centimeters. The hematocrit readings prior to injection were 39 per cent and 35 per cent, respectively. After 6 days these values fell to 14 per cent in each instance. The preliminary plasma protein levels were 5.1 and 5.65 grams per cent, respectively, and after 8 days' injection fell to 2.27 and 1.57 grams per cent, respectively, and were maintained at these levels by repeated injections. The reduction in levels of circulating plasma proteins paralleled roughly the reductions in hematocrit readings. Bromsulfalein liver function test in 1 animal after 13 days' injection was within normal limits. These studies were interpreted to indicate that an inert colloid could be injected to dilute the blood plasma and that plasma protein levels were correspondingly reduced because outpouring of plasma from the tissues into the circulation, if it did occur at all, was insufficient to elevate the plasma protein level above that expected from the dilution.

Another control observation was the determination of the dilution effects of gelatin injected daily as has been described. It was not anticipated that gelatin alone would suffice as an efficient nutriment since it does not include all essential amino acids. It was necessary, however, to determine if gelatin, repeatedly injected, would afford hemodilution as did gum acacia. The data obtained in 2 animals are summarized in Table I. Prior to these experiments the animals were depleted of protein by maintenance on a low nitrogen diet (1 gm. of the diet contained 1 mgm. nitrogen).

The results show that hemodilution resulting from repeated injections of gelatin is not comparable in degree with that observed following gum acacia, in that the latter probably remains in the circulation for a longer period.

Still another type of control observation carried out was the demonstration that gelatin injected intravenously was not inert but was at least partially catabolized by the organism. For example, in 1 patient receiving nothing by mouth and only saline solution by vein, the average daily urea nitrogen excretion was 2.8 grams for 3 days; when 11 grams of gelatin were injected each day for 3 days, the average daily urea nitrogen excretion was 7.5 grams, and on the subsequent 3 days when saline only was again injected, the urea nitrogen excretion was 3.2 grams per day. Explanations other than that the increased urea excretion was derived from catabolism of some of the gelatin would appear farfetched.

In a study to determine the utilization of a given nutriment administered intravenously, it is necessary to determine its efficiency when

[1] Brunschwig, A., Corbin, N., and Johnston, C.D. Ann. Surg., 1943, 118: 1058-1063.

From the Department of Surgery, University of Chicago.

TABLE I.—EFFECTS OF REPEATED DAILY INTRAVENOUS INJECTIONS OF GELATIN ON PLASMA PROTEINS

	Onset of experiment	Termination	Average daily regimen during 27 days
Dog 613			
Weight—kgm.	7.46	7.1	Caloric intake—low nitrogen diet—445 calories Nitrogen in diet—.45 gm. Nitrogen in intravenous gelatin—4.6 gm. Injected daily—315 c.c. (25.3 gm. gelatin)
Hematocrit—per cent	48	30	
Hemoglobin—gm.	16	11	
Red blood cells—M.	6	4	
Plasma protein—gm. per cent	5.1	4.2	
Dog 542			
Weight—kgm.	13.7	12.6	Caloric intake—low nitrogen diet—882 calories Nitrogen in diet—.82 gm. Nitrogen in intravenous gelatin—9.3 gm. Solution of gelatin injected daily—640 c.c. (51.2 gm. gelatin)
Hematocrit—per cent	51	38.5	
Hemoglobin—gm.	16	12.7	
Red blood cells—M.	6.4	4.1	
Plasma protein—gm. per cent	5.0	4.6	

ingested orally since the purpose of intravenous nutrition is to achieve results that approach those obtained by oral ingestion. Previous studies, amply confirmed, have shown that gelatin as the sole protein in the diet does not permit of adequate nutrition, but that this deficiency is compensated for by addition of proper supplements of amino acids. It was anticipated that intravenous gelatin as the principal source of protein would require amino acid supplements for anabolic utilization if indeed this would be at all possible.

Studies were conducted in 4 dogs in which protein depletion was obtained by maintenance on a low nitrogen diet, gelatin plus amino acid supplement then added to the diet, and finally in 2 of the dogs, gelatin feedings were continued but the amino acid supplement was withdrawn. The results are summarized in Table II. After periods of 23 to 37 days on the diet with gelatin and amino acid supplement there was appreciable elevation of the circulating plasma protein level. When, in 2 dogs, the amino acid supplement was withdrawn, the circulating plasma proteins decreased to previous levels. The amino acids added consisted of d-tryptophane, dl-iso-leucine, l-cystine, dl-valine, dl-methionine, dl-threonine in quantities of 1 per cent each of the total daily intake of gelatin.

The next step was to determine if intravenous gelatin with amino acid supplement could be utilized for plasma protein regeneration. Four dogs previously depleted of protein by maintenance on a low nitrogen diet received intravenous gelatin supplemented by 4 amino acids, viz. dl-tryptophane, l-cystine, dl-valine and dl-iso-leucine. The data summarized in Table III indicate little efficiency of utilization in 2 instances (dogs 683 and 723) in that the level of circulating plasma proteins decreased. However, in 2 instances (dogs 626 and 744) there was maintenance of this level, previous control studies in other animals indicating that on the diet alone, a progressive decrease in plasma proteins averaging .5 gram per cent per week invariably occurs. The maintenance of the plasma protein levels might suggest at least minimal utilization. The decrease in hematocrit readings suggest that hemodilation cannot be regarded as im-

TABLE II.—GELATIN PLUS AMINO ACID SUPPLEMENT* AS DIETARY PROTEIN

Prior to depletion					At onset of experiment						Dietary regimen		At termination of experiment				
Dog	Wt. kgm.	Hemat. %	R.B.C. M.	P.P. gm. %	Wt. K	Hemat. %	Hb. gm.	R.B.C. M.	P.P. gm. %	Period days	Low N. diet, Calories	Gelatin and amino acids gm.	Wt. kgm.	Hemat. %	Hb. gm.	R.B.C. M.	P.P. gm. %
175	16	49	5.5	6.35	9	44	14	5.4	4.6	37	566	30.1	10.9	30	13	4	5.95
176	7.45	49	6.1	6.85	41	38	12	3.6	4.5	35	296	15.2	4.6	30	12	3.9	5.47
305	6.63	52	6.6	5.97	4.7	41	15	5.4	5.2	23 20	280 280	16.0 15.0 No amino acids added	5.4 4.9	39 41	13.7 13.8	4.8 4.8	5.94 5.2
310	9.5	52	5.5	6.75	6.4	42	13.4	5.1	5.15	23 20	390 390	22 20.7 No amino acids added	6.9 6.7	40 43	13.4 14	4.6 5.0	5.7 4.78

* Amino acids added: d-tryptophane, dl-iso-leucine, l-cystine, dl-valine, dl-methionine, dl-threonine in quantities of 1% each of daily intake of gelatin.

TABLE III.—INTRAVENOUS FORTIFIED* GELATIN AS THE SOURCE OF NITROGEN FOR NUTRITION

Dog	Period days	Total calories, low nitrogen diet	Intravenous nitrogen as gelatin (plus amino acids)*	Variations in weight and circulating plasma protein levels.					
				Onset of experiment.			Termination of experiment.		
				Wt. kgm.	P.P. gm. %	Hemat. %	Wt. kgm.	P.P. gm. %	Hemat. %
626	21	360	2.64	3.5	5.0	50	3.1	5.22	37
683	22	400	2.62	3.9	4.6	47	3.5	3.66	20
723	14	320	2.38	5.1	4.6	44	5.6	4.02	18
744	15	420	2.65	5.75	4.5	45	5.7	4.5	24

*Tryptophane, cystine, valine and iso-leucine, 1 per cent each of total quantity of gelatin injected daily.

portant since gelatin in the blood stream causes a shrinkage of volume in the individual erythrocytes and this affords decrease in hematocrit values out of proportion to a degree of hemodilution that may obtain.

When gelatin plus the six amino acid supplement was injected intravenously each day in dogs depleted by previous maintenance on low nitrogen diet only, evidence of utilization for protein regeneration was observed in that there was an elevation of the circulating plasma protein level at the end of 24 days despite evidence of hemodilution. The data in 2 dogs are summarized in Table IV. Blood volume studies (Evans blue) showed increases in the quantities of circulating plasma proteins.

CLINICAL OBSERVATIONS

Intravenous gelatin was employed in over one hundred human patients for the treatment and prevention of shock as a plasma substitute, and for nutritional purposes. Among the first hundred patients there were 8 reactions. These consisted of mild to moderately severe chills and rise of 2 to 3 degrees (F.) in temperature. The reactions were ephemeral and not followed by significant sequelae. Three of the 8 patients also exhibited similar reactions when receiving normal saline solution or blood transfusions; another had hyperthyroidism. Several patients, some of whom have received as much as 2400 cubic centimeters of 8 per cent solution of gelatin within 24 hours have now been followed for many months and exhibit no disturbances ascribable to the injections. In no instance was there suppression of urine incident to the intravenous administration of gelatin; some of the patients did have chronic nephritis.

In the series of human patients, gelatin with amino acid supplement was not injected as in the dogs here described. However, while receiving such injections patients were also given casein digest (amigen) or they received food protein by mouth. The casein digest, and/or food, was regarded as the source of essential amino acids that were not included in gelatin.

Data obtained in 3 of the patients on nitrogen balance studies who received intravenous gelatin follow.

TABLE IV.—INTRAVENOUS FORTIFIED* GELATIN AS THE PRINCIPAL SOURCE OF NITROGENOUS NUTRIMENT

Prior to depletion	Onset of experiment	Termination of experiment	Average daily regimen
Dog 426			
Weight—kgm. 7.0	5.5	5.3	Period—24 days Caloric intake—low nitrogen diet—330 calories Nitrogen in diet—.33 gm. Nitrogen in intravenous gelatin—3.8 gm. (387 c.c.)
Hematocrit—per cent 50	48	28	
Hemoglobin—gm.	14	9.2	
Red blood cells—M. 6.9	5.9	3.8	
Plasma protein—gm. per cent 6.85	5.4	6.00	
Dog 347			
Weight—kgm. 11	7.85	8.67	Period—27 days Caloric intake—low nitrogen diet—470 calories Nitrogen in diet—.47 gm. Nitrogen in intravenous fortified with gelatin—4.1 gm. 512 c.c.
Hematocrit—per cent 40	41	29	
Hemoglobin—gm. 14.6	14.6	12	
Red blood cells—M. 5.45	5.2	3.1	
Plasma protein—gm. per cent 6.33	5.5	5.62	

In dog 426, blood volume (Evans blue) at onset of experiment was 312 c.c.; circulating plasma protein, 16.8 gm. Blood volume (Evans blue) at termination of experiment was 342 c.c.; circulating plasma protein 20.5 gm. Net gain in total plasma protein, 4.5 gm.

In dog 347, blood volume at onset of experiment was 445 c.c.; circulating plasma protein, 24.5 gm. Blood volume at termination of experiment was 525 c.c.; circulating plasma protein, 29.0 gm. Net gain in total plasma protein, 4.5 gm.

*Six amino acids added in quantities of 1 per cent each of total amount of gelatin injected daily viz.: l-tryptophane, dl-iso-leucine, l-cystine, dl-valine, dl-methionine, dl-threonine.

Patient K., No. 344120, female, aged 34 years, convalescent from a radical colectomy and enterectomy performed for extensive regional enteritis, was markedly depleted before operation due to severe diarrhea.

During a period of 7 days' observation, the following facts were noted:

Average daily nitrogen in diet—grams	11.0
Average daily nitrogen (intravenous) gelatin—grams	11.2
Average daily calories in diet	1812
Average daily total nitrogen intake—grams	22.2
Average daily nitrogen excretion—grams	14.7
Average daily nitrogen balance	+7.5

The above depleted convalescent patient was enabled rapidly to achieve an average daily positive nitrogen balance of 7.5 grams. Seven months after operation she remains well.

Similar data in another patient again indicate the value of intravenous gelatin in increasing nitrogen retention. A period of 6 days' observation while gelatin was administered was followed by a period of 5 days when gelatin was not injected:

Patient R., No. 305306, female, aged 35 years, a convalescent from excision of the head of the pancreas and duodenum for carcinoma of the former. Six months after operation patient is well.

	Period I 6 days	Period II 5 days
Average daily (intravenous) gelatin—grams	11.5	0
Average daily nitrogen in diet—grams	5.	7.4
Average daily calories in diet	820	1573
Average daily total nitrogen intake—grams	16.5	7.4
Average daily nitrogen excretion—grams	12.8	6.3
Average daily nitrogen balance—grams	+3.7	+1.1

Data in a third patient who received all nutriment intravenously follow:

Patient Nels, No. 356063, male, aged 58 years, was suffering from carcinomatosis, primary in the stomach.

	Period I 9 days	Period II 4 days
Average daily (intravenous) gelatin—grams	11.2	11.2
Average daily nitrogen (intravenous), casein digest—grams	6.0	0.0
Total nitrogen (intravenous)—grams	17.2	11.2
Intravenous glucose—grams	150	200
Average daily nitrogen excretion—grams	16.3	15.3
Average daily nitrogen balance—grams	+ .7	−4.1

A slight positive nitrogen balance was possible when gelatin and casein digest were injected, whereas when gelatin alone was injected there was pronounced negative balance. This may be explained by the inadequacy of gelatin alone as a nitrogenous nutriment whereas combined with casein digest all essential amino acids were afforded.

DISCUSSION

Parenteral nutrition by means of nitrogenous substances is in its early stages of development. Undoubtedly, as progress in this field continues, newer types of solutions will be developed to afford increased efficiency of utilization and to include factors the essentiality of which are not as yet appreciated.

The studies summarized herein indicate that certain gelatins may be employed for the parenteral administration of nitrogen and that nitrogen in such form is anabolically utilized. The principle demonstrated is that a nonantigenic protein may be administered parenterally and is at least partially utilized if essential amino acids which it may not contain are otherwise available.

SUMMARY

Experimental studies in dogs indicate that a certain type of gelatin administered intravenously is at least partially utilized for regeneration of plasma proteins.

Clinical experience indicates that intravenous gelatin constitutes one method by which nitrogenous substances for nutritional purposes may be administered.

INDICATIONS FOR ROENTGEN THERAPY OF BLADDER CARCINOMAS

Recognition of Suitable Cases

FRANZ BUSCHKE, M.D., and SIMEON T. CANTRIL, M.D., Seattle, Washington

RADIATION therapy of carcinoma of the bladder comprises several procedures: external roentgen therapy, contact roentgen therapy through the suprapubic wound, interstitial irradiation by means of removable radium needles or implantation of radon seeds into the tumor. The following discussion deals exclusively with external roentgen therapy of the bladder in an attempt to gain a working basis for indications of this type of treatment in the management of bladder carcinoma in contrast to other radiological and surgical procedures.

Roentgen therapy of cancer in general has two distinct aims: palliation or permanent cure. Palliative and radical curative roentgen therapy differ fundamentally in indications and technique in spite of the quite widespread misconception that an incomplete course of irradiation might still afford some palliation even if it does not completely sterilize the cancer. Usually in such instances the added injury of incomplete irradiation will rather aggravate the condition.

Palliative roentgen therapy, to be sure, has its well defined place in the management of certain incurable cancerous manifestations, but its scope is much narrower than is generally assumed and patients have to be selected as carefully as for the radical procedure. In the treatment of those cancers of the bladder which are considered incurable by surgical or radical radiological procedures because of the extension of the disease or the general condition, radiation therapy with the purpose of palliation only has no place. It is useless and in many instances harmful. The amount of irradiation necessary to produce sufficient tumor response to cause even an appreciable retardation of growth will, if the tumor remains uncontrolled, cause so much discomfort by increased frequency and pain with corresponding deterioration of the general condition that the term "palliative" becomes meaningless. Very occasionally the use of irradiation as a hemostyptic agent may be considered. Usually, however, the hemostyptic effect, if accomplished at all, will be of only very short duration unless a marked actual tumor response is induced. In short, the procedure necessary to produce even a temporary tumor regression for the types of cancer encountered in the bladder is of a magnitude out of proportion to its possible results even in cases in which it does not actually aggravate the condition. The damnable practice of giving "a few light treatments" for psychological reasons in hopeless cases will only discredit the procedure in the minds of those surgeons and urologists who do not yet appreciate the value of radical roentgen therapy for carefully selected suitable cases.

Radical roentgen therapy, in the meaning of this term as we shall presently define it, is young. It dates from 1922 when Regaud, Coutard and Hautant demonstrated 6 patients with inoperable cancer of the larynx treated and cured by x-ray therapy. For the first time the fact was established that for certain types of tumors radiation therapy is superior to surgery; that surgery and radiation therapy do not compete with each other; that each procedure has its own indications. The fundamental principle of radical radiation therapy which Coutard has taught us is the careful adaptation of the treatment to the requirements of the individual patient (type of tumor, extension, general condition, response to treatment) under the guidance of detailed daily examination. In this way—and in this way only—is it possible to push the dose to the necessary tumor sterilizing level without causing intolerable permanent damage to the sur-

From the Tumor Institute of the Swedish Hospital, Seattle.

rounding structures. During the two decades that followed this fundamental and epochal demonstration, we have learned to apply this type of treatment to certain tumors—such as those of the larynx, pharynx, and cervix—with a degree of certainty that their treatment has passed the stage of the clinical experiment and is now considered as a well established clinical procedure, not a last resort in hopeless cases. Accumulated experience has taught us to recognize certain factors as decisive for the recognition of suitable cases, for the determination of the prognosis, and for the actual conduct of therapy: the histological type of the tumor, its exact location and extension, and the general condition of the patient. We have learned, for example, that the all inclusive diagnosis of carcinoma of the larynx is meaningless unless it is qualified by a detailed description of the place of origin (true cord, false cord, epiglottis, etc.) and extension (mobility or fixation, invasion of muscle or cartilage, etc.).

In the treatment of cancers of the bladder, this stage has not yet been reached. In certain instances bladder cancers have responded to roentgen therapy satisfactorily enough to demonstrate the essential radiovulnerability of these tumors and to encourage further attempts. As a whole, however, it seems from a review of the literature that the treatment has been given in a more or less haphazard and unsystematic fashion in regard to the selection of cases and the technique used. In general one gains the impression that more often than not roentgen therapy in bladder carcinoma is resorted to only as a last attempt after the urologist has failed.

The main reason for this unsatisfactory state of affairs is probably an insufficient cooperation between the urologist and the radiation therapist. As has been pointed out before, the fundamental requirement for radical roentgen therapy is a careful adaptation of the procedure to the requirement of the individual case. We have seen radiologists treating bladder carcinomas without ever having looked into these bladders or without having studied the microscopic section of the biopsy. It is impossible to treat adequately a carcinoma of the larynx or cervix without detailed appraisal of the individual situation by the radiotherapist himself; the same is naturally true for carcinoma of the bladder. The personal examination cannot be fully replaced even by the best description. Naturally the radiation therapist cannot be a specialist in all fields but he must have enough working knowledge in the borderline specialties to enable him to interpret intelligently the findings in close collaboration with the respective specialist. In the conduct of treatment for carcinoma of the bladder in comparison to larynx and cervix, we are somewhat handicapped by the impossibility of regular inspection of the local response, since of course frequent cystoscopies during and immediately following treatment even in the best hands would aggravate the treatment reaction and induce serious complications. But a detailed preliminary examination by the radiation therapist in collaboration with the urologist is essential.

From the experience with other tumors it can be assumed that probably only certain types of bladder carcinomas, if any, would be suitable for this kind of treatment, while others may be more benefited by other procedures such as surgical excision, fulguration, or interstitial radium application. Real progress can be expected only by correlating the success or failure with the details of the individual case treated—with respect to type, location, extension of tumor, general condition of the patient, complicating features such as infection and obstruction as well as considering the details of the procedure used.

With these ideas in mind we analyzed, in 1941, the 44 cases of carcinoma of the bladder treated in this Institute between 1934 and 1939 with external supervoltage therapy (1). At that time we reached certain tentative conclusions regarding contraindications and indications, which since then have been used as a working basis to guide us in the selection of suitable cases. Again in 1942 we reviewed our material of 52 patients treated between 1934 and 1940 (2). A summary of the entire group of patients treated by this procedure during the 10 year period between 1934 and 1943 is given in Table I.

The experience of others (3, 4, 5, 6), as well as our own in certain carcinomas of the blad-

der demonstrates the possibility of cure with external roentgen therapy. The details of the apparently cured cases, including photomicrographs, were presented in our previous reports. Our increased experience since the first reports has substantiated our conclusions regarding the contraindications for this procedure. Regarding indications, we have to modify our conclusions somewhat in so far as we have seen some patients apparently cured who have shown types of tumors originally considered unsuitable for this type of therapy.

In analyzing the failures as well as the successes we are led to the conclusion that 5 main factors seem to be decisive for the indication for roentgen therapy: (1) the biological type of tumor, (2) extension of the disease, (3) general condition of the patient, (4) previous therapy of any kind, (5) technique of treatment.

THE BIOLOGICAL TYPE OF TUMOR

As in malignant tumors of other organs, the biological type of tumor is probably the most important single factor. The possibility of sterilizing certain malignant tumors by ionizing radiation is due to one of nature's whims which has endowed certain normal and abnormal cells with a sensitivity to this type of irradiation. By trial and error on the basis of empirical experience we have learned to recognize certain tumors as radiovulnerable and others as resistant to ionizing irradiation. In carcinoma of the bladder, our experience is still too young to make final conclusions. It seems, however, that the tumors most suitable for irradiation are the papillary carcinomas without invasion of the bladder wall. In our former reports we have stated that all of our patients treated successfully belong to this group. At that time we emphasized that we were not in full agreement with other reports in the literature in which successful treatment of invasive bladder tumors by x-ray therapy was reported. During the last years we have had occasion to treat 2 patients who belong in this group and whom we first very reluctantly accepted for treatment because of the invasive character of the tumor. So far they have shown so complete and persistent a disappearance of the tumor that in all likelihood they will remain cured. In these cases the diagnosis of the invasive character was made on the cystoscopic as well as the microscopic evidence. We have, however, no way to tell whether the invasion in these cases extended into the muscular structures of the bladder or was limited to the mucous membrane itself. Experience with cancers of other organs has shown that the curability decreases with progressive invasion of the adjoining muscular structures. We believe, therefore, that the most suitable types for radiation therapy are the papillary carcinomas without marked invasion of the bladder wall. It must be kept in mind that this invasion may not be demonstrable at the first cystoscopy or by preliminary biopsy examinations because only the papillary portion of the tumor intruding into the bladder may be resected for biopsy. An experienced urologist, however, can recognize the bladder wall involvement to a certain degree. The picture may be masked by a secondary inflammatory reaction and in these instances the infiltration may be less real than apparent. On the other hand, certain growths can be definitely recognized as infiltrating growths by cystoscopic examination, palpatory findings, and histological examination. We do not believe that a cancer of the bladder, once it has deeply infiltrated the muscular structures or has extended beyond the bladder itself, is still a suitable object for radiation therapy. Some infiltrative growths, as long as the infiltration remains fairly superficial, may still occasionally be sterilized.

TABLE 1.—SUMMARY OF 69 CASES DURING 10 YEAR PERIOD 1934–1943

Year	No. treated	No. well to date	Dead or alive with active disease	Lost
1934	9	3	5	1
1935	10	1	6	3
1936	12	1	11	0
1937	1	0	1	0
1938	6	0	6	0
1939	6	1	5	0
1940	8	1	7	0
1941	9	1	8	0
1942	5	1	4	0
1943	3	1	2	0
Total	69	10	55	4

On the other hand we have seen recurrences in cases of very low grade papillary carcinomas (which by some pathologists would be termed papilloma or malignant papilloma) following a course of supposedly adequate therapy. On the basis of this yet very limited experience, it would seem that the most suitable carcinomas are the recurrent papillary carcinomas of a moderate degree of differentiation, those which the urologist considers as beyond his control by repeated fulguration.

EXTENSION OF THE DISEASE

From the foregoing discussion it becomes evident that regardless of the type of tumor, the extension of the disease will have a marked effect on the outcome. While naturally cases with demonstrable distant metastases are beyond treatment, one might at times be tempted to treat those which locally have extended beyond the bladder proper. If we feel that the invasion of the bladder muscle itself already demarcates the limits of curability by roentgen therapy, obviously cases with involvement of the perivesicular structures are beyond therapeutic approach. In former years in practically all patients seen the disease had extended beyond the surgeon's reach. It was for this reason that they were referred for roentgen therapy. During recent years the situation has changed and due to our increased experience with indications and contraindications, and in closer co-operation with the urologists, we now receive patients for treatment who technically could still be treated by surgical procedures but for whom the urologists now too feel that roentgen therapy may offer a better chance because of the recurrent character of this type of lesion.

GENERAL CONDITION OF THE PATIENT

As in roentgen therapy for other cancer, we have seen that the appraisal of the general condition of the patient quite generally is underestimated in the decision as to indications for roentgen therapy. Consequently, it is believed that if a patient is unsuitable for surgery because of his general condition, roentgen therapy might still be attempted. Very rarely should the general condition be a decisive factor for determination of surgical versus radiological indications. With the exception of occasional instances of specific contraindications, such as cardiovascular disease which prohibits surgery, patients who are refused surgery on account of their general condition will not support a treatment of such magnitude as radiation therapy. In many a physician's mind radiation therapy of cancer still seems to be a kind of glorified ultraviolet or diathermy. It must be realized that radical radiation therapy with the purpose of cure represents a procedure of such formidable magnitude that it will be supported only by patients in good general condition. It is mainly the lack of appreciation of the meaning of the term radical roentgen therapy which leads physicians and patients alike to believe that a few light treatments might accomplish miraculous results. Actually the treatment of a cancer of the bladder requires daily treatment for about 6 to 8 weeks. Following the therapy a bladder reaction will develop leading to frequency of urination and pain. The intensity of this reaction varies within wide limits. It depends partly on the location of the tumor, the condition of the bladder mucosa in general, and on the individual sensitivity. If the tumor is located in the dome the reaction usually will be less marked than if it is located in the trigonal region encroaching on the urethral orifice. A tumor located in the lowermost portion of the bladder necessitating irradiation of the prostatic urethra will lead to a very marked reaction with considerable distress. The reaction in men usually is more intense than in women. Marked infection of the bladder mucosa outside of the tumorous portion will also markedly increase the intensity of the bladder reaction. If this is associated with a urethral obstruction by either tumor or prostate interfering with bladder drainage, the reaction may be so intense that the actual deterioration of the patient's condition becomes dangerous. Frequency and pain under these conditions interferes so markedly with the patient's general condition that it makes the continuance of adequate radiation therapy impossible. We now refuse patients for treatment in whom either a severe infection is present or adequate drainage cannot be established. In cases in which it is possible

to remove either the enlarged prostrate or the occluding tumor mass to re-establish drainage we ask for this procedure prior to roentgen therapy. If the drainage is either adequate from the beginning or is re-established, one might cautiously begin radiation therapy for the accompanying infection. The treatment itself in some cases may improve the infection, at which time the more intense therapy for the carcinoma can be established. However, if we do not succeed in combating the infection before the more intense roentgen therapy begins we are very soon handicapped in the adequate conduct of treatment, which will not be successful.

From this discussion it becomes evident that patients in a poor general condition are not suitable objects for this kind of therapy. We have found, however, that age in itself in an otherwise well preserved body without accompanying infection and not too far advanced disease does not represent an absolute contraindication to the treatment.

PREVIOUS THERAPY

Suprapubic operation preceding roentgen therapy considerably lowers the possibility of adequate irradiation. We have observed the breakdown of a suprapubic scar shortly after irradiation in 2 patients. In both cases the contributing factor to the breakdown could be found in an increased intravesicular pressure from interference with adequate drainage. We believe, however, that in spite of these additional difficulties, the previous suprapubic operation itself is a severe handicap to adequate irradiation. If roentgen therapy is considered, we feel, therefore, that either a suprapubic cystotomy should be avoided or should be done high enough to keep the scar outside the field of irradiation. This latter procedure may sometimes be used when an attempt at suprapubic resection may be preferable yet a recurrence of a type of carcinoma suitable for roentgen therapy later on may be considered.

Occasionally, patients have been referred after unsuccessful treatment by means of interstitial irradiation. As in all other kinds of carcinoma these patients are not suitable for further irradiation. Cancer therapy by irradiation is an all or none procedure. If the first attempt fails, success can practically never be expected by further irradiation. The tissues do not tolerate the dose necessary for sterilization of the tumor after they have received previous radiation therapy. The tumor itself has become more radioresistant and due to fibrosis is less amenable to further irradiation. If interstitial irradiation has been given by means of permanently implanted seeds, the presence of the metal with a secondary irradiation in its immediate neighborhood will add to the necrotic effect of the irradiation and jeopardize the treatment even more than previous radiation therapy by other procedures. It is obvious, therefore, that these patients should be refused for roentgen therapy.

The situation is somewhat different with regard to previous fulguration. Indeed, the most favorable cases for roentgen therapy of the bladder are apparently those that show recurrent papillary carcinoma. In these instances fulguration has usually been attempted, and the patient is referred at a time when the recurrence becomes either too widespread or develops too rapidly for further fulguration. These cases are still suitable for roentgen therapy provided the growth has not invaded too far into the bladder wall. If roentgen therapy is considered, it should not be done immediately following a recent fulguration. If, in a case in which fulguration has been done once or twice, roentgen therapy is considered for a new recurrence, the surgeon should refer this patient for radiation therapy without any further attempts to fulgurate. The necrosis following fulguration will only intensify the bladder reaction and complicate the proper conduct of therapy.

TECHNIQUE OF TREATMENT

We do not intend to discuss the technical details of the therapy but we wish to emphasize a few points which we believe have been the cause of failures in a number of our cases. The main technical errors which may lead to failure in cases primarily considered as curable lesions may be due to misjudgment of the field size in relation to the tumor or to insufficient or too rapid treatment. Led by cystoscopic examination which showed the tumor area limited to one side of the bladder, we have

tried to increase the dose to this area with corresponding diminution of the dose on the contralateral portion. We have abandoned this procedure because we have observed definite progression of the tumor on the undertreated side. It is probably not possible to judge exactly the limitation of the field in the bladder itself, and it is necessary to include the entire bladder in the field during the whole course of treatment. Furthermore, it seems necessary to treat the entire bladder in the recurrent papillary growth (the most suitable type for roentgen therapy) in order to prevent recurrences in other parts of the mucosa.

In one case we have observed recurrence of a papillary carcinoma in the lowermost portion of the trigone close to the bladder neck while the remaining bladder remained clear throughout the observation time. Since we had no other reasons to explain this localized recurrence we feel that in all likelihood it was due to an underdose in this most peripheral area of the field.

In 2 cases of our series, a severe pelvic fibrosis developed, undoubtedly due to overtreatment. In 1 case the bladder capacity became so reduced due to the bladder fibrosis that a transplantation of the ureters was found necessary. In this case the ureters were found dilated to about 4 times normal size and the kidney pelves dilated and infected. This patient died subsequent to transplantation. In another case the final outcome was not fatal, but such a marked rectal fibrosis developed that a regular rectal dilatation became necessary to avoid complete rectal obstruction.

These patients were treated during the early years of the use of supervoltage roentgen therapy when the danger to the deeper structures was not sufficiently appreciated. We have since then learned to avoid these severe reactions and no severe by-effects due to treatment have been observed so far in the cases observed in the last 6 years. It should be particularly pointed out that necrotic ulcers in the bladder, which are at times found after treatment of uterine carcinoma, have never been observed in roentgen therapy of bladder carcinoma. This indicates that they are most likely due to faulty technique in the radium application in cancers of the cervix rather than to the external irradiation. In cases of carcinoma of the bladder which are controlled, cystoscopy usually does not show any remnant of the disease or any appreciable trace of the preceding irradiation. In most instances it is impossible for the urologist to recognize the location of the former lesion unless there is some area of atrophy or superficial scarring. In most cases the bladder mucosa appears normal unless the tumor was very extensive.

Rectal reactions of any degree of intensity likewise are not observed when the technique has been carefully controlled. Most of our patients are treated through 3 fields, one central anterior port, and two oblique lateral ports centered toward the bladder. In this way the rectum receives its main irradiation through the anterior port only, while most of the rectum is spared by the posterior fields. Only very occasionally we have observed even a transitory diarrhea.

We believe that the use of supervoltage roentgen therapy in the treatment of bladder carcinoma has a decisive advantage over the use of the lower voltages. It is possible to administer a tumor sterilizing dose through 3 comparatively small fields. With the lower voltage this tumor dose could be obtained only by a large number of fields because the skin of one single field would not tolerate the amount which it is possible to administer with supervoltage radiation. When the number of fields is increased each single field also must be larger because the aiming toward the bladder from any but the 3 fields mentioned is difficult and in order to include the entire bladder, the field has to be fairly large. It thus necessitates a greater volume dose throughout the body, quite frequently accompanied by more intense general reaction.

SUMMARY AND CONCLUSIONS

Of 68 patients with advanced carcinoma of the bladder treated between 1934 and 1940 with 800 kilovolt roentgen irradiation, 10 are so far clinically well and cystoscopically without evidence of disease. Seven of these are well and have remained well for more than 4 years. The analysis of the successes and failures had led to certain tentative conclusions with regard to indications and contraindica-

tions of this procedure. We wish to emphasize that we do not consider these conclusions final but only a working basis for further investigation.

Contraindications. External roentgen therapy of the type here discussed for carcinoma of the bladder is a formidable procedure. Only patients in good general condition will support such a major procedure. Adequate bladder drainage and capacity, and absence of marked infection are prerequisites for a fair trial by this method. Previous suprapubic operation, particularly in the presence of any obstruction or infection, constitutes an additional hazard to intense irradiation.

It is self evident, therefore, that this method is not a procedure suitable for palliative purposes. Cancers inoperable because of extravesicular extension have not been benefited.

Indications. While increased experience during the last years has shown that our adherence to the contraindications as outlined is justified, we have somewhat modified our position with regard to the indications. The most suitable cases for radical roentgen therapy are the extensive papillary carcinomas in which infiltration cannot be demonstrated. If papillary carcinomas recur after repeated fulguration or if the surgeon feels that a certain type of carcinoma will probably recur after fulguration, roentgen therapy is indicated without further delay, if it is considered at all. We mean that one should make up his mind in a particular case whether it should be treated by roentgen therapy or by some other procedure. If roentgen therapy is chosen it should not be requested as a last resort when the conditions for success have become considerably lessened by infiltration, poor general condition, or associated infection.

The likelihood of cure by roentgen therapy is less marked in infiltrative growths. While there are some reports in the literature and in our own series substantiating the belief that certain infiltrative carcinomas might still be cured, we believe that the likelihood of control becomes practically nil when the bladder muscle is invaded. We cannot yet determine with certainty whether those patients who have benefited showed an infiltration of the bladder mucosa only without true infiltration of the bladder wall, but, from our experience with other carcinomas, it is obvious that with progressing infiltration control by roentgen therapy is correspondingly decreased. Carcinomas that have developed beyond the bladder wall and have become palpable by rectal examination are beyond cure. It must be considered that occasionally an infiltration might be apparent which may be due to accompanying inflammatory infiltration rather than true carcinomatous extension. It must also be kept in mind that the histological examination of the removed specimen may be misleading. The biopsy obtained from the periphery of the growth may not demonstrate deeper infiltrative portions of the tumor. A loop resection biopsy, adequately done, may give more adequate information than a biopsy taken only from the surface of the growth.

We feel, therefore, that a small carcinoma of a primarily infiltrating type is better handled by surgical excision, if this is feasible. If the lesion is so located that a complete bladder resection is the only surgical procedure possible, interstitial irradiation, preferably in the form of implantation of removable radium needles, is probably superior to roentgen therapy provided the actual size of the tumor is not beyond about 3.5 centimeters in diameter.

With increasing experience we hope better to differentiate these tumors—those which are suitable for roentgen therapy from those which receive more benefit from other procedures. Progress, however, can be expected only by a careful selection of cases and impartial analysis of successes and failures. This can be accomplished only by close co-operation between urologist and radiotherapist.

REFERENCES

1. Buschke, Franz, and Cantril, Simeon T. Radiation Therapy; a Supplement to the Staff Journal of the Swedish Hospital, May, 1941, No. 2, p. 77.
2. Idem. J. Urol., Balt., 1942, 48: 368.
3. Cutler, Max, Buschke, Franz, and Cantril, Simeon T. Cancer, Its Diagnosis and Treatment. P. 323. Philadelphia: W. B. Saunders & Co., 1938.
4. Ferguson, R. S. Am. J. Roentg., 1936, 36: 73.
5. Herger, C. C., and Sauer, H. R. J. Urol., Balt., 1943, 50: 310.
6. Pfahler, G. E., and Vastine, J. M. J. Am. M. Ass., 1935, 104: 609.

REFLEX SYMPATHETIC DYSTROPHY

JAMES A. EVANS, M.D., Boston, Massachusetts

REFLEX sympathetic dystrophy is a most disabling, often extremely painful, malady following minor sprains, ordinary fractures, or, in military or civil life trauma to blood vessels or nerves. The syndrome is characterized only at times by the excruciating, burning pain that has given it the term "causalgia," hence a misnomer. Pain may be moderate, mild, or absent. The true diagnostic features are those disorders initiated by perversions of reflex sympathetic stimulation, namely increased rubor or pallor, sweating, edema, atrophy of skin, and spotty or even cystic atrophy of bone.

Mitchell, Morehouse, and Keen wrote the first brilliant description of this distressful phenomenon, based on cases of gunshot wounds to nerves and blood vessels in the Civil War. Sudeck described cases of painful joint involvement, giving rise to the term, Sudeck's syndrome. Leriche pointed out most vividly the role of the sympathetic system in the pernicious reflex, and Homans, in his presidential address to the Massachusetts Medical Society in 1940, brilliantly described the picture and cure of several cases of "minor causalgia." To Livingston, in his scholarly monograph entitled *"Pain Mechanisms"* I would wish to give credit for the clearest theoretical elucidation of the reflex itself. In the diagram and ideas expressed in this article, I have borrowed heavily from his theory to explain the vicious circle producing the syndrome of reflex sympathetic dystrophy.

MECHANISM OF REFLEX SYMPATHETIC DYSTROPHY

Figure I illustrates diagrammatically the nervous pathways giving rise to the syndrome of reflex sympathetic dystrophy. The fundamental concept of the internuncial pool (Fig. 2), advanced by Lorente de Nó and adopted by Livingston, can be explained simply as follows. A prolonged bombardment of pain impulses sets up a vicious circle of reflexes spreading through a pool of many neuron connections upward, downward, and even across the spinal cord, and perhaps reaching as high as the thalamus itself. Because of the summation principle of nervous impulses, there is kept alive within such a pool a constant circling of activity across the synapses involved. Some of these synapses include the sympathetic motor neuron cells in the lateral horn controlling vasomotor tone and the sweat glands. Spasm in the arteriolar and venule end of the capillary loops raises filtration pressure, and edema and swelling result. Cyanosis and anoxemia increase capillary permeability and filtration, further augmenting edema. Other synapses involved may be the anterior motor horn cells, giving rise to skeletal muscle cramps and spasms. Out of the pool also arise augmented stimuli to pain traveling up the thalamic tract. Depending on the wide spread of the pool we detect the phenomena of pain and sympathetic disturbances observed a long distance from the injured area in the limb and occasionally even spread to the contralateral limb. The afferent pathway is represented as the sensory nerve fibers traveling in the posterior root since, according to Livingston after careful review of the evidence, pain-bearing fibers do not exist in the sympathetic somatic system. Therefore, the abolition of pain by severance of the sympathetic pathway is not due directly to any blocking of afferent pain fibers but to an interruption of the efferent sympathetic pathways leading from the internuncial pool. It must be noted, however, that pain relief is not always complete and further measures must be taken, as noted in the paragraph on treatment.

ETIOLOGY

In the past 3 years I have gathered mainly from the orthopedic service, the neurosurgical service, and a few from the medical and surgical services of the Lahey Clinic, 32 cases of reflex sympathetic dystrophy. The exciting trauma or diseases are as follows: sprain, 9;

From the Department of Internal Medicine, The Lahey Clinic.

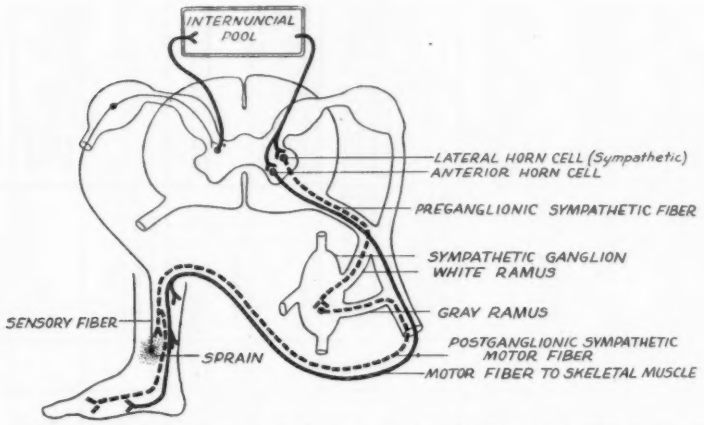


Fig. 1. Reflex arc of sympathetic dystrophy embodying Lorente de Nó's theory of the "internuncial pool" (Fig. 2).

fracture, 5; thrombophlebitis, 4; poor foot statics, 3; bruise, 2; amputation, 2; scalenus syndrome (?), 2; laceration of hand, 1; anterior poliomyelitis (?), 1; plantar wart, 1; gonorrheal arthritis, 1; thalamic syndrome (cerebrovascular accident), 1. In addition there were the complications of fungus infection in 3 and operative interference in 3. Mindful of conceiving of these cases as reflex sympathetic dystrophy and not necessarily causalgia, I have included cases which showed undoubted sympathetic vascular or sweating phenomena and only incidentally pain. This concept has led me to include 4 cases of thrombophlebitis. Injury to blood vessels in the form of arterial injury has been reported before as a cause for causalgia (Homans, Weir Mitchell, and associates); thrombophlebitis is less often recognized as a possible source of causalgia. In 3 of the 4 cases of thrombophlebitis, muscle cramps have been an outstanding feature of the pain. One of these 3 patients had no constant pain but only cramps. One patient with reflex sympathetic dystrophy, with a history of "torn ligaments" in the wrist 10 months before and operative interference 4 months later, had no pain, but the sympathetic phenomena of rubor, swelling, and hyperhydrosis were present to a marked degree.

Injuries in the form of sprain, fracture, bruise, lacerations, and amputations together accounted for 59 per cent of the cases. Three of the patients suffered from poor foot statics, the respective diagnoses being pronated feet, relaxed feet with metarsalgia, and pes planus.

Two cases of scalenus syndrome (unproved by operation) are included because the scalenus pressure had produced Raynaud's syn-

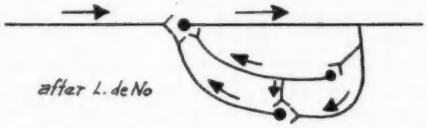


Fig. 2. Internuncial pool—closed self-re-exciting chain.

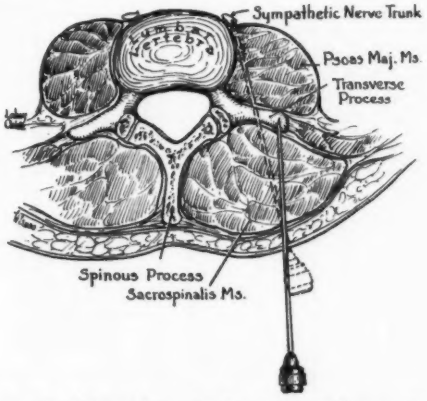


Fig. 3. Technique of paralumbar sympathetic procaine block. (Fom Nicholson, Anesth. and Analg., May-June, 1942.)

TABLE V.—RÉSUMÉ OF 32 CASES

Case Admission date	Original injury	Pain	Trigger points	Rubor	Pallor	Swelling	Sweating	Skin	Atrophy muscle	Bone	Cramp	Block	Sympathectomy
1 11–20–43	Anterior poliomyelitis at 5	Extreme, 28 yrs. Causalgia.	+	++		+	++	−	−	−	−	Relief	90% improved in 1 yr. 10 mos.
2 2–16–44	Sprain 9 mos. before	Mild 9 mos.		+	−	+	−	−	+	+ (Mottled)	−	Relief	90% improvement 2 mos.; by x-ray less bone atrophy
3 10– 8–44	Fracture 2d metatarsal; operation, removal of exostosis	Severe, 6 mos.	+	+		+	−	−		+ (Mottled)	−	Relief with trigger point gone	3 wks. relief of causalgia but pain persists from osteomyelitis in 2d metatarsal
4 8–14–44	Pes planus	Moderate, 6 mos.	−	−	−	+	−			+ (Blotchy)		100% relief 1 mo. (proper shoes also)	
5 6–13–44	Gonococcus arthritis 8 yrs. ago; hyperhydrosis rt. leg followed by fungus ulceration; hypertension	Swollen sore rt. big toe 8 yrs. Causalgia.		+	−	+	++			+ aseptic necrosis rt. toe	−		Splanchnicectomy for hypertension; 100% relief of pain 3 mos.; ulcers healed
6 8– 7–44	Postpartum thrombophlebitis 8 yrs. ago; venogram positive	Moderate, 6 yrs.; severe, 2 yrs.	+ Over popliteal vessels	−	−	−	−	−	−		−	3 wks. 100% immediate relief; disappearance of trigger point	
7 9– 7–44	March fracture of tibia; ?history of thrombophlebitis; negative venogram; contusion to knee	Moderate, 9 mos.	+	+ (With purpura)		++	+	−	−	−	−	75% relief on 3 blocks 2 mos.; swelling subsided; trigger points gone	Sympathectomy recommended later if result of blocks is not permanent
8 9– 7–44	Laceration dorsum rt. hand 1 yr. ago; later 2 operations on hand	Causalgia severe 1 yr.	+		+		+		+	+		No relief	50% relief 3 mos.; needs much physical therapy and injection of trigger points
9 6–28–44	Plantar wart	Excruciating, 9 mos. Causalgia.	+	+	−	+	−	−	−		−	Recommended	
10 2–28–44	Fracture of radius	Severe, 1 yr.	+		+	+	+	+	+	+	−	Relief	Marked 11 days
11 6–25–42	Superficial thrombophlebitis in varicose veins	Severe	+	+			+	−	−		++	2 blocks, 1 caudal; 75% relief 1 yr.	
12 3–27–41	Pronated feet	Moderate	−	−	−	−	−	−	−		−	Relief 50%	
13 12– 1–43	Sprained ankle	Moderate	+	−	+	+	−	−	+ (Entire leg)	+ (Entire leg)	−		9 mos. 25% improvement; needs injection of trigger points and physical therapy
14 11– 8–44	Old thrombophlebitis	−	−	+	−	−	+	−	−		++	Recommended	
15 12–30–41	Sprain 3 yrs. ago; fungus infection	Severe, 1 yr.	−	+		++	++			+ (Cystic)	−	Relief	2 mos. 95% improvement
16 9–18–44	Torn ligaments in wrist 10 mos. ago; operative interference 6 mos. ago	−	−	+	−	+	++	−	−	+		Recommended before any further operative procedure	

TABLE V.—RÉSUMÉ OF 32 CASES—Continued

TABLE V.—RÉSUMÉ OF 32 CASES—Continued

Case Admission date	Original injury	Pain	Trigger points	Rubor	Pallor	Swelling	Sweating	Skin	Atrophy muscle	Bone	Cramp	Block	Sympathectomy
17 3-25-43	Relaxed feet; metarsalgia	Moderate (intermittent claudication)	−	−	−	−	++	−	−		−		1 mo. 90% improvement; foot exercise needed
18	Sprained wrist 20 yrs. ago	Severe 3 yrs. in wrist on effort, also at rest, nitro relief	−	−	−	−	−	−	−		−	Recommended to differentiate from angina	
19 12-10-43	?Scalenus syndrome with Raynaud component	Severe	+	−	+	+	+	+	−		−	Relief	Sympathectomy
20 8-22-44	Probable herniated disk, L4-5; syphilis, congenital (well treated); sprained foot 4 mos. ago	Severe, left foot 4 mos.	+		+	−	−	−	−	Mottled left foot		Relief on 3 blocks	75% improvement of numbness; 100% improvement of pain 1 month
21 5-19-43	?Scalenus; quadrilateral Raynaud's; menopause; epidermophytosis	Moderate, 1 yr.	−	+	+	−	+	−	−		−	Relief	No relief of pain; increased warmth only
22 9-27-44	Accidental amputation 5th finger 16 mos. ago; cervical arthritis	Severe, 15 mos.	−	+	−	−	+	+	+		−	Relief	90% relief 2 weeks only, then relapse
23 1-15-43	Bruise palm of rt. hand 1½ yrs. ago	Severe, 1½ yrs.	+	+	−	+	+	−	+		−	Recommended	Recommended
24 3-25-43	Thrombophlebitis for 7 wks.; vitamin B deficiency; sciatica	Severe, 7 wks.	+	−	−	+	+	−	−		+	Relief after 6 blocks; 100% improvement of cramps	1 yr. later Raynaud's syndrome developed; intensive vitamin B therapy helped sciatica; sympathectomy may be needed for Raynaud's
25 2-24-43	Cerebral hemorrhage; "thalamic syndrome"	Extreme, 3 yrs. Causalgia.	+	−	−	−	−	+				Relief temporary	Recommended
26 4- 8-43	Sprained ankle 8 mos. ago	Moderate, 8 mos.	−		−	+		−	−		−	Recommended	
27 11-12-43	Trauma to rt. forearm 1 yr. 7 mos. ago; ?malingering	Moderate, 1 yr. 7 mos.	+	−	−	−	−	−	+	−	−	Relief temporary	
28 8-28-42	Mangled hand; amputation 2 fingers 5½ mos. ago	Dull, 5½ mos.	+ (in scar)	−	+	−	+	−	−	−	−	Recommended	
29 12- 2-43	Compound fracture left foot 2½ yrs. ago	Moderate, 2½ yrs.	+	−	+	−	+	−	−	−	−	Recommended	
30	Sprain both ankles 4 mos.	Severe, 7 wks.	−	−	+	−	+	−	−	−	−	Recommended	
31 7- 3-42	Sprain left foot 5 mos. ago; epidermophytosis	Moderate, 5 mos.	+	+		+	−	−	−	+ (Cystic)	−	Recommended	
32 3-11-44	Fracture metatarsal 6 mos.	Severe, 6 mos.	+	+		+		−	−	+	−	Relief for 3 wks. (injection trigger point also)	Recommended

drome, together with constant pain, relieved by cervical sympathetic procaine block.

In one case a plantar wart gave rise to excruciating pain in the foot, associated with rubor and swelling of 9 months' duration.

A patient who had had gonorrheal arthritis of the foot 8 years before retained a swollen, sore, big toe for 8 years. Roentgenogram of the toe demonstrated an aseptic necrosis, and physical examination revealed rubor, swelling and hyperhydrosis, associated with fungoid ulcers. Severance of the lumbar sympathetics abolished pain and led to healing of the ulcers after abolition of the excessive sweating.

One patient with thalamic syndrome who had hemiparesis following a cerebrovascular accident experienced temporary relief of causalgic pain in her right arm after cervical sympathetic block with procaine. This surprising result might arouse much speculation on the mechanism of so called thalamic pain. Opportunities to repeat this observation are needed.

A single case is reported here of terrific causalgic pain for 25 years that may have followed infantile paralysis at the age of five.

Local operative interference may only exacerbate the reflex sympathetic dystrophy already well established, as occurred in 3 cases. In such cases, sympathectomy is advisable before the necessary local surgical procedure is attempted. Fungus complications in the fertile soil created by hyperhydrosis seemed to increase the severity of the symptoms in 3 cases.

PAIN

Pain is usually the most prominent feature in reflex sympathetic dystrophy. It may be one of the most excruciating pains human flesh is heir to, a deep burning agony throughout an entire foot, hand or limb, that makes a patient wince as one approaches him with the examining hand, a pain that sometimes makes him contemplate suicide. Trigger points are often multiple and pressure on one often spreads a diffuse pain of a burning, peculiar nature up and down the limb. More often, in less severe cases, the pain response stays definitely localized to the trigger point. In our 32 cases, trigger points, single or multiple, were found in 19. Pain was excruciating and of a burning, causalgic nature in 5, rated severe in 12, moderate in 11, mild in 2, and none existed in 2 cases. These last two patients showed other signs of reflex sympathetic dystrophy.

OTHER SYMPTOMS AND SIGNS

Rubor was present in 15 and pallor in 9 cases. The rubor may be so constant and the foot or hand be so hot that the picture of erythromelalgia is produced. Livingston has suggested that rubor is often present in early cases, pallor in the more chronic cases. This has not been my impression in this series; in 6 cases rubor was present and of 1 year's duration or more, and in 1 case for as long as 28 years. Swelling or sweating or both was present in over half of the cases. Atrophy of the skin was noted in 4 and of muscle in 7 patients. The typical bone atrophy of sympathetic origin is mottled, in advanced cases even cystic, presumably owing to nutrient artery spasm. Such bone atrophy was described in the roentgenograms of 6 patients in this series. A diffuse osteoporosis resembling that of disuse was noted in 5 cases. Trigger points were noted in 19 cases.

DIAGNOSIS

Either cervical or paralumbar sympathetic procaine block comprises a diagnostic therapeutic test. The relief of pain may be almost miraculous but need not be so dramatic as to establish the diagnosis, provided relief of other phenomena is also noted, such as relief of sweating, increased warmth and comfort in a cold member, associated with rise of skin temperature (temperature index test), and disappearance of trigger points. Nineteen of our 32 patients had blocks performed, with varying amounts of relief in all but one.

TREATMENT

The ideal point of attack would be the internuncial pool itself. So far, no direct effective means is at hand to stop the vicious circle within this pool of neuron synapses.

Two other points of attack exist: the trigger points and the sympathetic pathway. Repeated injections of the trigger points usually are necessary. If the sympathetic pathway is blocked by procaine, one is occasionally grati-

Fig. 4. Fig. 5. Fig. 6.

Fig. 4. Case 2. Mottled bone atrophy of reflex sympathetic dystrophy (Sudeck's syndrome).
Fig. 5. Case 3. Marked mottled type of bone atrophy.
Fig. 6. Case 5. Gonorrheal arthritis 8 years before admission; no evidence of gonorrheal activity at present. Aseptic necrosis of both phalanges of right great toe; diffuse osteoporosis of disuse. Condition was cured by splanchnicectomy.

fied by the astounding relief obtained with only one injection. More often, there are relapses within a few days or weeks and repeated injections are necessary at longer and longer intervals. It would seem more logical to give a series of three injections, one every second day, for more permanent rupture of the pernicious reflex, a method so successfully applied to thrombophlebitis (Fig. 3).

At the clinic we have felt it best to resort to sympathectomy in the majority of our treated cases after the demonstration of the efficacy of one block in order to obtain the maximum of relief and the greatest assurance of permanency of relief.

Posterior root rhizotomy, cordotomy or, for high cervical segment, interruption of the thalamic pathways in the medulla and even resection of the sensory cortex may be necessary in exceptional cases.

Nineteen patients received sympathetic procaine block, with varying amounts of relief of pain and sympathetic phenomena in all but one. Nine patients were treated by block alone. Of these 9, 7 had 50 to 100 per cent relief of pain for 3 weeks to permanent relief. Two of the 9 received only temporary relief for the duration of the procaine effect. Only 1 patient was treated by injection of trigger points as well as by sympathetic procaine block, with relief of pain for only 3 weeks. A sympathectomy is to be done on this patient. Thirteen patients have had sympathectomy with pain relief ranging from 75 to 100 per cent in 9 (69 per cent). Failure to 25 per cent relief resulted in 4 of the 13 cases.

ILLUSTRATIVE CASE REPORTS

Case 1. A woman, aged 30 years, came to the clinic November 20, 1943, because of extreme causalgic type of pain in the right leg for 25 years following an attack of what may have been anterior poliomyelitis at the age of 5 years. There was marked rubor, moderate swelling and marked sweating, and several trigger points were present. The pain was so extreme that she had developed a conditioned reflex, with the hands breaking out into sweat if one made a motion toward her foot as though to touch it. She took a half hour in the morning to put her shoes on because her right foot was so tender.

Paravertebral sympathetic block afforded marked temporary relief. Sympathectomy was performed,

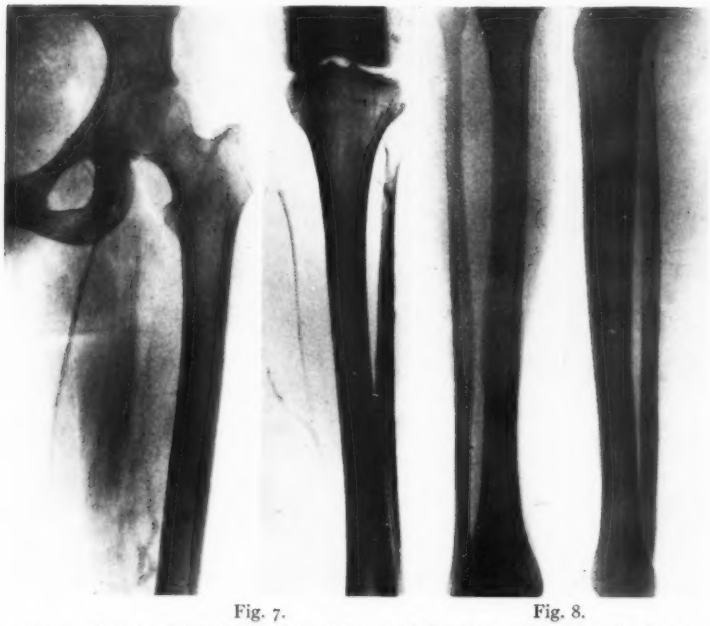


Fig. 7. Fig. 8.

Fig. 7. Case 6. Thrombophlebitis of 8 years' duration. Venogram showing no filling of deep venous circulation.
Fig. 8. Case 7. Callus of old "march fracture."

with 90 per cent relief of pain and 100 per cent relief of rubor, swelling, and excessive sweating when the patient was seen 1 year and 10 months later. There was still slight tenderness over the trigger points behind the external malleolus below the lateral aspect of the right knee. The patient was most grateful.

CASE 2. A woman came to the clinic February 16, 1944, because of mild pain, rubor, swelling, and slight muscle atrophy which had been present ever since she sprained her ankle 9 months before admission. The roentgenogram showed mottled bone atrophy (Fig. 4). Paravertebral sympathetic block afforded temporary relief. Sympathectomy was done, with 90 per cent relief of pain in 2 months. At this same time a roentgenogram showed less bone atrophy.

CASE 3. A man had sustained a fracture of the second metatarsal followed by operative removal of exostosis 6 months before admission to the clinic, October 8, 1944. For the past 6 months there had been severe pain in the foot. Trigger points, rubor, swelling, and bone atrophy were present (Fig. 5). Paravertebral sympathetic block afforded relief, with disappearance of trigger points. Sympathectomy was done, and after 3 weeks there was relief of the causalgic pain. However, pain was still persistent in the foot from the osteomyelitis of the second metatarsal. A colored photograph 3 weeks after operation showed definitely less rubor and swelling.

CASE 4. A man came to the clinic August 14, 1944, because of moderate pain in the right foot of 6 months' duration. There was definite swelling and a blotchy type of bone atrophy. There was no history of trauma but marked pes planus was present. One month after one paravertebral block, 100 per cent relief of pain was obtained. The patient also had proper shoes fitted.

CASE 5. This man came to the clinic June 13, 1944. He had suffered from gonorrheal arthritis 8 years before admission. There had never been complete subsidence of pain in his right big toe and foot. Hyperhydrosis had been present, complicated by fungus infection, with ulceration. Rubor, swelling, and marked sweating were apparent. A roentgenogram showed an aseptic necrosis in the toe (Fig. 6). The patient also had essential hypertension. For this reason a splanchnicectomy rather than sympathectomy was done. There was 100 per cent relief of the pain in the right foot and toe. Three months later his foot was dry and the ulcers had healed. A check-up roentgenogram of the toe showed the same aseptic necrosis present.

CASE 6. A woman came to the clinic August 7, 1944. She had suffered postpartum thrombophlebitis 8 years before admission. For the last 6 years there had been moderate pain, which had grown much more severe during the last 2 years. A trigger point was present over the popliteal vessels. A veno

gram (Fig. 7, a and b) showed failure of deep venous filling in the calf and thigh. A paravertebral sympathetic block afforded 100 per cent relief for 3 weeks, following which there was a relapse. It is planned to inject the trigger point and repeat the paravertebral block.

CASE 7. A college girl, aged 21 years, came to the clinic September 7 1944. She had suffered moderate pain in the right lower leg following a fall skating 9 months before admission. Marked swelling and rubor developed. For the past 2 months purpuric spots had appeared over the right lower leg. Sweating had become pronounced. Soon after the fall she was confined to bed with what was called the "flu." At this time she had fever and red streaks on her leg. A venogram at the time of her hospital entry showed normal filling of the deep calf veins and the femoral vein in the thigh. There was normal capillary fragility in the affected leg. Coagulation time, bleeding time, and platelets were normal. A roentgenogram of the tibia revealed the callus of an old "march fracture" (Fig. 8).

This patient was treated with a series of three paravertebral sympathetic procaine blocks in 1 week. At the end of the week the swelling had subsided and the trigger points had disappeared. She was seen 2 months later, and pain was completely relieved.

CASE 8. A woman had sustained a laceration on the dorsum of the right hand a year before being seen at the clinic, September 7, 1944. Two operations had been performed on the hand in the hope of relieving severe causalgic pain of a year's duration. Trigger points, pallor, sweating, and muscle atrophy were present. Roentgenograms demonstrated diffuse bone atrophy. Paravertebral block afforded no relief. Nevertheless, sympathectomy was done, with 50 per cent relief of pain 3 months later. This patient needs much physical therapy which it is now possible to give because the limb is so much less tender to manipulation. Injections of trigger points are advised.

CASE 9. A man came to the clinic, June 28, 1944, because of a plantar wart, with excruciating pain through the foot for 9 months. A trigger point was present over the wart. Rubor and swelling of the foot were noted. Paralumbar sympathetic block was recommended but refused.

SUMMARY

Reflex sympathetic dystrophy is described as a syndrome produced often by minor trauma or disease in a limb leading to the reflex production of the sympathetic phenomena of rubor or pallor, heat or cold, increased sweating, edema, and pain. Since the factor of pain may be absent, the term "reflex sympathetic dystrophy" is preferred to causalgia.

The rôle of Lorente de Nó's "internuncial pool" in the production of the syndrome of reflex sympathetic dystrophy is presented.

Traumatic injury accounted for only 59 per cent of the 32 cases reported.

The typical bone atrophy of reflex sympathetic dystrophy is mottled or cystic (Sudeck's syndrome).

Diagnosis depends largely on the demonstration of relief by sympathetic procaine block. Nineteen of the 32 patients received sympathetic block with procaine, with varying amounts of relief of pain and sympathetic phenomena in all but 1 patient.

Treatment may be directed to blocking the trigger points if they exist and to blocking the sympathetic pathway. In 9 patients treated by sympathetic procaine block alone, 7 had relief of pain varying from 3 weeks to permanent, such pain relief estimated at 50 to 100 per cent. The other 2 received relief of pain only for the duration of the procaine effect.

Thirteen patients of the 32 here reported had sympathectomy performed, with relief of pain ranging from 75 to 100 per cent in 9, or 69 per cent. Failure to 25 per cent relief of pain resulted in 4 of the 13. The 2 patients who had no pain but other sympathetic phenomena have so far not submitted to either block or sympathectomy.

REFERENCES

1. HOMANS, J. N. England J. M., 1940, 222: 870–874.
2. LERICHE, R., and POLICARD, A. Physiologie pathogique, chirurgicale inflammations, effets des traumatismes, réparation des plaies, greffes, maladies des os, des articulations, des vaisseaux et des nerfs. Paris: Masson et Cie, 1930.
3. LIVINGSTON, W.K. Pain Mechanisms: A Physiological Interpretation of Causalgia and its Related States. Chap. 14. New York: The Macmillan Co., 1943.
4. LORENTE DE NÓ, R. J. Neurophysiol., 1938, 1: 207–244.
5. MITCHELL, S.W., MOREHOUSE, G.R., and KEEN, W.W. Gunshot Wounds and Other Injuries of Nerves. Philadelphia: J. B. Lippincott Co., 1864.
6. SUDECK, P. Arch. klin. Chir., 1900, 62: 147–156.

A SINGLE-STAGE OPERATIVE METHOD OF MANAGEMENT OF CHRONICALLY INFECTED, UNUNITED FRACTURES

FRED G. HICKS, M.D., F.A.C.S., Quebec, Canada

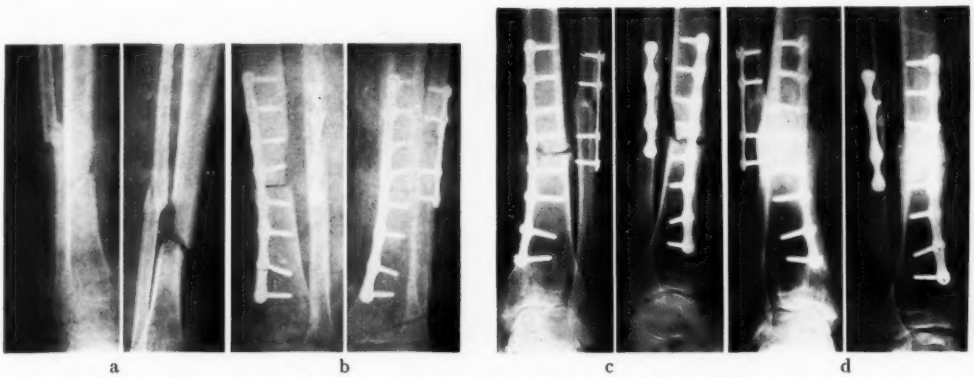
COMPOUND fractures of the long bones are seen relatively frequently among war casualties; particularly favored for this injury are both bones of the leg. Unfortunately, a rather high percentage of these cases become infected and later present the picture of chronic osteomyelitis or soft tissue infection and nonunion. Review of statistics reveals that there has been an increase in the incidence of faulty union during this war, seen in both simple and compound cases in spite of the use of the sulfonamides and penicillin. In a good number of cases treatment was delayed by transport difficulties; others were wounded previous to routine use of the drugs.

In the far past, because of a long line of unhappy experiences, a markedly conservative restriction was placed upon surgical interference in cases with infection. Operation was mentioned only to be condemned. Recently, since the advent of the chemotherapeutic agents which render the infecting organisms avirulent, practice has been to administer preliminary supportive and specific therapy, then at operation to excise the infected tissues as thoroughly as possible and secure drainage. After subsidence of the infection, a grafting operation is performed. This accepted procedure has been, and still is for certain cases, the one practiced here. However, a number of protracted convalescent periods while cure of the infected area was awaited, and one case of relighting of a latent infection some months after bone grafting, caused a different procedure to be adopted with a certain type of patient.

Particular concern was shown over cases with marked loss of bone substance and ones with lengthy infection. In these instances, in view of the extensive fibrosis of soft tissues with marked sclerosis and atrophy of the main-fragment ends, it seemed that the preliminary operation for excision and drainage could not possibly remove all the factors of latent infection, to prepare for grafting. The length of convalescence before rehabilitation could begin was not in the best interest of the patient's mental outlook and general health; equally important, it endangered the preservation of function of the limb involved. This latter factor was of most serious import, as the prolonged immobilization would lead to irreparable contracture and fibrosis of the musculature and periarticular structures, resulting in partial or complete permanent disability of the limbs. A resultant united fracture in a limb, with stiff or painful joints, would leave much to be desired. In patients with long standing osteomyelitis and moderate-sized bony defects, we believed that a departure from previous practice might be made before amputation was considered.

A group of patients was chosen for more radical procedure. Eleven cases with long bone involvement are illustrated below; similar circumstances have been successfully treated in small bones. The patients were adults in the various armed services who received compound fractures in the line of duty, with subsequent infection. All infections were in the quiescent state when treatment was begun. Some patients revealed frank osteomyelitis, while others suffered from chronic infection of soft tissues, with or without dispersed small bone fragments. Most of the patients showed a flail-type of nonunion, plainly evident at physical examination. The technique of the single-stage procedure upon leg cases, consisting simply of a radical osteotomy and excision of infected soft tissue with internal fixation by plating, will be given in outline to avoid repetition.

From Ste. Anne's Military Hospital, Ste. Anne de Bellevue.



a b c d

Fig. 1. Case 1. a, Preoperative views; b, 1 day postoperative; c, 8 weeks postoperative showing the usual absorption and bone regeneration; d, 1 year postoperative.

PRELIMINARY PROCEDURE

1. Roentgenological investigation is made of the involved bones and adjacent joints. Sinuses are injected with radio-opaque material to determine recesses, location of foreign material, and such conditions.

2. General condition is investigated thoroughly and an intensive therapeutic period is instituted with bed rest; this includes frequent whole blood and plasma transfusions, high protein and vitamin intake (vitamin C is stressed).

3. Sulfathiazole is given orally to maintain a blood level of 5 milligrams per cent.

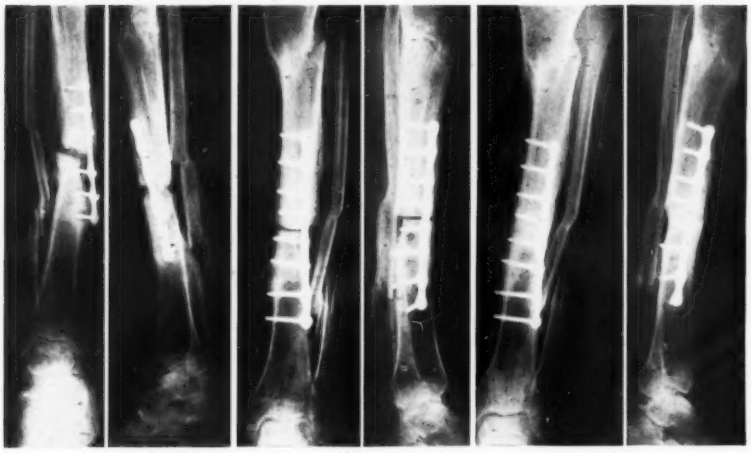
4. In several instances dictated by investigation, other medication, such as thyroid extract, is instituted.

5. Mild physiotherapy in form of gentle massage and movement is applied to the adjacent muscles and joints. No specific treatment of the local condition is adopted other than adequate splinting and the usual cleansing of sinus regions by shaving, compresses, or dry dressings. For 12 hours previous to operation, alcohol dressings are applied.

The length of this treatment depends upon the degree of general depletion of each patient and the local skin condition; in most instances the skin is severely crusted and granular from lengthy closed-plaster therapy.

OPERATION

After skin preparation of the whole limb, a generous longitudinal incision, allowing wide exposure without tension on the skin, is made. The incision includes encircling of sinus openings and is placed 2 inches medial or lateral to the anterior tibial crest. The incision is deepened to expose the tibial periosteum. If possible, without sacrifice of the closure, all skin scar is excised at this time. However, at times the excision of noninfected skin scar is delayed for a future plastic operation. Pains are taken not to traumatize the skin edges. Sinus tracts and all devitalized tissues are excised completely; loose bony fragments are removed but fragments which are deeply embedded, far from the fracture site and which have no apparent connecting tract, are not disturbed. The tibial periosteum over healthy bone is split and reflected about the whole circumference; in most instances it is absent or replaced by scar over the infected region. After the tibia has been separated from its bed, the two main fragments are usually separated transversely by scalpel. At times the central block of eburnated bone and infected granulation tissue are removed *en masse* by saw, but in the majority of cases to allow resection of the bone at the proper levels, the former measure has to be taken. The amount of the main fragments to be removed is more or less predetermined by x-ray evidence of the extent and degree of bone sclerosis. The ends of the bones are sawed squarely across to expose freely bleeding marrow canals circumscribed by healthy cortex free of infected granulations. No heed is



a b c

Fig. 2. Case 2. a, Preoperative views; b, 2 months postoperative; d, 7 months postoperative.

paid at this time to length conservation; the minimal requirement is that the segments to be approximated be viable. With such an increased exposure, the soft tissue bed of the fracture site, consisting of dense scar interspersed by small pockets of granulation tissue are thoroughly excised, care being taken to preserve main arterial and nerve trunks. It is then necessary similarly to expose the fibular fracture site through separate, or the same, incision and accord it the treatment described. If the fibula has not been fractured, or more commonly if it has healed without infection, an equal length of its shaft is excised by saw; occasionally, it is cut across obliquely to allow its fragments to override without removal of a portion. If the tibia is markedly porotic, the fibula is transected low down so that the superior fragment crosses the tibial fracture to be incorporated in that bone for added strength. The main tibial fragments are then accurately approximated in proper alignment and maintained so by an 8-screw vitallium plate. The plate is applied to the anterior surface of the tibia opposite to the incision site, e.g., if the incision is necessarily anteromedial, the plate is fixated to the anterolateral tibial surface. (As in fresh-fracture plating, certain principles are helpful: (a) the plates used are long, (b) the screws are placed eccentrically for added purchase, (c) the screws penetrate the opposite cortex, (d) if wire is used it is of the same metal). The wound is then thoroughly irrigated with normal saline and "dusted" with sulfathiazole powder. The skin and subcutaneous flaps are closed if possible in a single layer of silk mattress sutures; no catgut is buried. If much skin has been lost the closure is difficult or impossible, even after wide undercutting of the flaps. In the event of incomplete closure the edges are approximated as well as possible and vaseline dressings are applied without any form of skin-grafting. A moderate pressure dressing, with cotton waste, follows. The limb is enclosed in plaster from upper thigh to toes with ankle at right angles and knee in 10 degrees' flexion. A long window is cut over the incision but it is left unopened.

These principles of technique are similar in the thigh and upper limb fractures, differing only in size of plate, and approach. Spinal anesthesia is used for all lower limb cases; cyclopropane and oxygen are chosen for those of the upper limb. All patients receive whole blood or plasma transfusion during operation.

POSTOPERATIVE

The preoperative regimen outlined is resumed. In most instances the sulfonamides

a b c

Fig. 3. Case 3. a, Preoperative views; b, immediate postoperative views. Note that the screws could not be used in lower fragment due to marked osteoporosis. c, Twelve months postoperative. Plate was previously removed at tendinoplasty.

are discontinued in the second week. The wound is inspected on the sixth day through the window and if there is any sign of infection, several central sutures are removed and warm saline compresses are applied. Otherwise, all sutures are removed on the ninth day. A walking plaster cast extending from the knee, is applied in 5 to 6 weeks and remains present until end of third month.

ILLUSTRATIVE CASES

Case 1. An infantryman received an explosion wound and was operated upon here 17 months following trauma. Examination revealed a compound fracture of both bones of leg with skin defect and discharging sinus from nonunited infected tibial fracture; the fibula was partially healed by fibrosis. Following operation, the wound healed completely. The use of walking caliper splints was begun in sixth postoperative week; patient was walking without any support 12 weeks postoperatively, with moderate evening ankle swelling. There were no signs or symptoms for 3 years postoperatively. Total limb shortening was 1¼ inches. (Fig. 1.)

Case 2. Patient was injured in a plane crash, and was operated upon here 11 months following original surgery. He also suffered fracture of other leg and skull. Examination revealed compound fracture of both bones with nonunion; very profuse purulent discharge with skin defect and projecting bone plate; osteomyelitis of tibial fragments only. Following operation, slight serous discharge continued only 10 days through the skin defect; wound was completely healed in 4 weeks. Walking by caliper splints was begun in fifth postoperative week. Patient was walking very freely without support by twelfth postoperative week. He was accepted for duty in Merchant Navy 8 months after operation. He had no complaints 2 years after operation. Total shortening of limb was 1 inch. (Fig. 2.)

Case 3. Patient was injured in a mortar explosion. He was operated upon here 14 months following wound. Examination revealed a compound fracture of both bones with nonunion; chronic osteomyelitis and sequestration at both tibia and fibula fracture sites; tibialis anticus and extensors all destroyed; moderate skin defect. There was a moderate amount of purulent discharge from the wound. After operation the wound healed completely. Walking by caliper splints was begun 6 weeks after operation. Patient was walking with no support to leg but foot straps in 15 weeks. There was no evidence of infection, etc., 2 years following operation. Function was restored by tendinoplasty. Total shortening was 1¼ inches. (Fig. 3.)

Case 4. Patient was injured in a plane crash. He also sustained fracture of pelvis and hip dislocation. He was operated upon here 3 months following trauma. Examination revealed a compound fracture of the tibia with grossly infected fragment ends; fibular fracture not infected. There was no sign of attempt at union and a discharging skin sinus was present. The wound healed after operation by primary intention. Walking by caliper splints was begun in 8 weeks; its application was delayed by other fractures. Walking without support was possible in sixteenth week and he was returned to duty. Total shortening ¾ of an inch. No disability for past 2 years. (Fig. 4.)

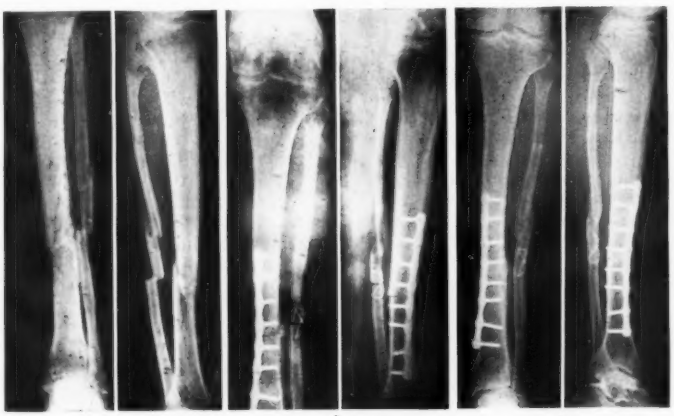
a b c

Fig. 4. Case 4. a, Preoperative views; b, immediate postoperative views—note lower leg fractures also; c, 6 months postoperative.

CASE 5. Patient was injured in a motor accident. One sequestrectomy had been performed. He was operated upon here 6 months later for flail-limb with discharging sinus. Examination revealed nonunion with chronic infection of tibia and sequestration. Osteotomy of both bones was performed. The wounds healed without complication. Walking cast was applied in 5 weeks; he was walking without support 3 months after operation. Total shortening was 1 inch. Elective removal of plate 2 years later revealed perfect union without evidence of infection. Full duty performed during the past 2 years without symptoms. (Fig. 5.)

CASE 6. Patient was injured in a plane crash and suffered compound fracture of both bones with ulcerated discharging wound and flail-limb. Operation was performed here 5 months following accident. Examination revealed nonunion with sequestra and small loculations of pus about the tibial fragment. The lower fragment was markedly osteoporotic. Following the osteotomy, the upper fibular fracture was placed across the tibial fracture. The wound healed completely. A walking cast was applied in fifth week and all splinting was removed after 3 months. Patient was on full flying-duty 7 months after operation. Total shortening was 1 inch. Plate was removed for inspection 1 year later; no residual infection was evident. He has had no complaints for past 2 years. (Fig. 6.)

CASE 7. This case is presented for comparison. Patient was injured in a motor crash. He also suffered a fractured spine. He had had a series of previous sequestrectomy operations. Operation was performed here 2 years following injury. The findings were compound nonunited flail-fracture of tibia with osteomyelitis and sequestration; fibular



a b c

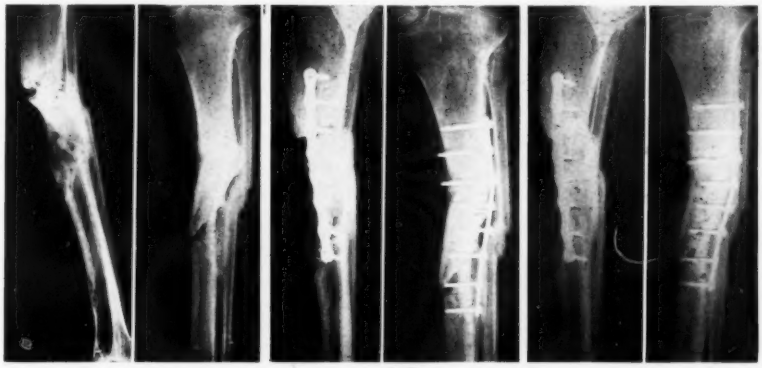
Fig. 5. Case 5. a, Preoperative; b, 1 month postoperative; c, 1 year postoperative.

a b c

Fig. 6. Case 6. a, Preoperative views; b, 5 weeks postoperative; c, 1 year postoperative.

fragments partially united and not infected. Also profuse discharge through multiple skin sinuses. In this case the usual osteotomy was not performed due to extensive sclerosis of large intermediate tibial fragment. The necrosed bone and infected soft tissues were thoroughly excised; plate was applied for stability. The wound healed primarily; one month postoperative a single small sinus formed and intermittently recurred for 1½ years, but discharged only "spots" of thin serum. Bone union progressed slowly. Patient walked without support in twelfth postoperative week. No shortening. Plate removed recently and bone was seen to be healed securely.

CASE 8. Patient was injured in a plane crash. He suffered compound fractures of both femora. Both bones were plated. The right femur united firmly with marked lateral bowing. The left femur was infected and nonunited. He was operated upon here 8½ months later. The findings were flail limb with gross infection of fragments, sequestration, and discharging sinuses. Considerable pus and marked loss of bone substance were noted; bone plate was very loose. The plate was removed and an osteotomy and plating were performed; wires were also used because of marked osteoporosis. Patient refused spica and only posterior thigh mold was used. The wound discharged small amount of thin pus for



a b c

Fig. 7. Case 7. a, Preoperative views; b, Two months postoperative; c, Six months postoperative.

a b

Fig. 8. Case 8. a, Preoperative view; b, 2½ months after operation. No evidence of infection about the screws. Usual changes for this period at osteotomy site.

3 weeks, then healed completely. An ischium-bearing walking caliper with crutches was allowed 6 months after operation. Patient refused further plastic bone repair and was transferred. When re-examined 1 year later, he was walking with a cane but no recurrence of infection was evident. Limb shortening was not significant as the opposite femoral bowing compensated. (Fig. 8.)

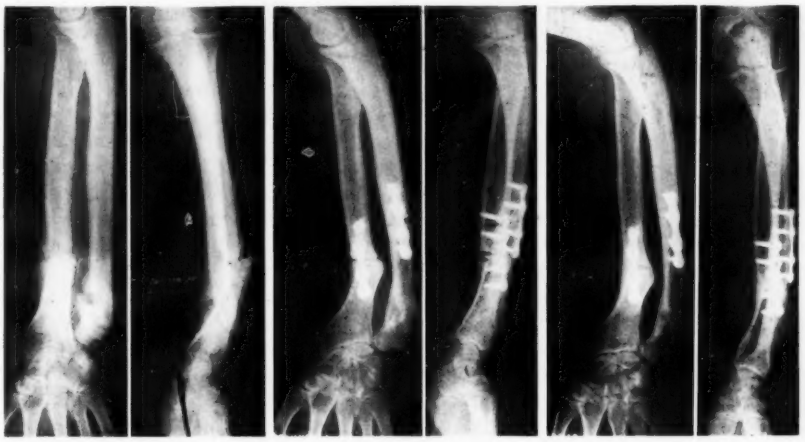
CASE 9. Patient was injured in a motorcycle accident. He received a compound fracture of the middle third and simple fracture of metaphysis of left femur. The upper fracture failed to unite; the lower one healed. Operation was performed 9 months after accident. The findings were: No discharging sinuses were noted but sequestra and burrowing pus pockets about fragment. Plate was placed anteriorly, away from skin incision. The wound healed completely. Posterior body leg cast was maintained 2 months. A walking caliper splint was applied at 3 months, and patient was able to return to college. The plate was removed for inspection 11 months later. He has had no complaint for past 16 months. Total shortening was 1⅛ inches. (Fig. 9.)

CASE 10. Patient was injured in a motor accident. Two subsequent sequestrectomy operations had been performed. He was operated upon here 5 months following accident. The findings were: compound fractures of both bones with distal radial fragment extruding and chronic infection of fragments of radius and of soft tissues. Flail limb. After osteotomy of radius and excision of infected granulations, the ulna was shortened through a separate incision. Following operation, the wound healed completely. The cast was removed after 6 weeks. Total shortening was ¾ of an inch. Functional return was complete. He has had no disabilities for past 12 months. Patient returned to duty as coal stoker. (Fig. 10.)

CASE 11. Patient was injured in a motor crash. Compound fractures had been openly reduced. He was operated upon here 4 months after accident. The findings were: Compound fractures of both bones of forearm with flail nonunion. Chronic infection of fragment ends with small sequestra and wire through ulna; sinus over dorsum of ulna. Following operation, the wounds healed completely. Splinting was substituted by sling in 4 weeks. All movements were complete. Plates were removed 4 months after operation without signs of infection.

a b c

Fig. 9. Case 9. a, Preoperative views; b, 1 day postoperative; c, 11 months postoperative.



a b c

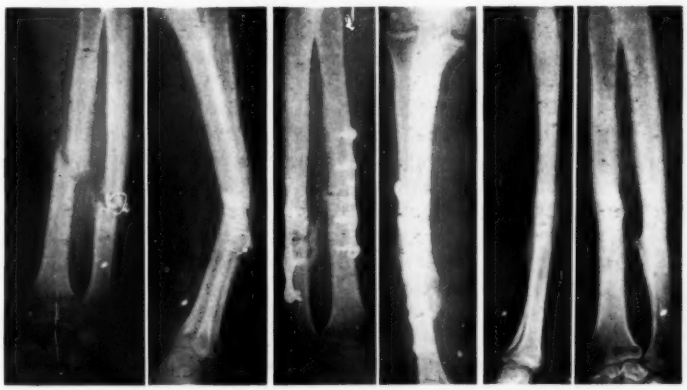
Fig. 10. Case 10. a, Preoperative views; b, Two and one-half months postoperative; c, One year postoperative.

Three years have passed without disability. Total shortening was ⅞ of an inch. (Fig. 11.)

OBSERVATIONS

This is not an established method of treatment and will undoubtedly be the subject of considerable diversion of opinion. Although exceptionally good fortune attended the patients, precisely the same sequence of events was noted in the clinical and x-ray progress toward secure union without undesirable sequelae; in no instance has there been occasion to regret the procedure. It did not seem that a lack of bone-forming capacity existed, once the grossly infected sequestra and soft tissues had been removed and vascular bone fragments were properly immobilized in apposition.

Without embarking upon discussion as to the etiological factor in the nonunion in these cases beyond the common one, infection, histories indicated that interrupted skeletal traction had most commonly occurred. Inadequate fixation, which is the expected



a b c

Fig. 11. Case 11. a, Preoperative views; b, Three months postoperative; c, Six months postoperative.

accompaniment of mobile war, plus a low vitamin C intake were strikingly constant.

While for the most part the ages of the patients were below 35 years, others represented the fourth and fifth decades.

The infection, unlike blood-borne osteomyelitis, was limited to the fragment ends and to surrounding soft tissues containing smaller loose bone, and therefore afforded opportunity for excision. The marked bony eburnation and surrounding avascular fibrosis inhibited elimination of infection solely by chemotherapeutic measures. Organisms were mixed, with staphylococci predominating, accompanied by streptococci, saprophytic organisms, Bacillus pyocyneus, and rarely Bacillus coli.

In no instance was there evidence of postoperative dissemination of the infective organisms, or a tendency toward local spread.

Importance of local or general administration of chemotherapy must not be overstressed; in several of the most grossly infected cases, use of drugs was omitted totally because of previously determined allergy.

There have been no residual sinuses or other unfavorable sequelae in those cases in which the full procedure could be performed. Case 7 is given as example of failure to eliminate completely infection in an instance in which an extensive osteotomy could not be done; osteogenesis was very slow and the bone spanning the infected area appeared sclerosed and brittle. The plate remained firm and maintained immobility during the lengthy healing period. Case 8, primarily very grossly infected, eliminated the infection very quickly and united in spite of small surfaces of bone apposed. In this instance, the procedure quickly afforded the abandonment of skeletal traction and eliminated the external reinfection of the wound. This latter factor is considered to be an important accomplishment of this procedure.

Postoperative pain was noted by its absence.

From x-ray and later operative examination, there is reason to believe that the enclosed metal does not form a formidable nidus for bacterial growth. Alarm that plates maintain the fragment ends in distraction during the early physiological period of resorption, resulting in non-union, is not justified by serial roentgenograms in the cases reported here; given time, firm union occurred. While the plates merely act as splints they can be credited with allowing security over the increased fragility period of bone healing and they allow considerably earlier movement of adjacent joints. (Particularly the ankle and foot.)

Several plates were removed to allow examination of the local area to verify complete absence of latent infection. The screw-holes did not fail to heal. Operation for plate removal in these cases is deemed unnecessary.

It will be noted that some bone loss occurred at the original injury; the operation further subtracted from the limb but the average total loss in length was 1 inch and did not exceed 1¼ inches. It must be remembered that a certain amount of length loss is also an accompaniment of a simple bone-grafting procedure in such cases, if the sclerosed bone ends are carefully resected. The shortening in this small series was compensated by the wearing of "shoe-lifts" which proved to be comfortable and non-disabling. The lower limb cases have been free of complaints, and follow-up observation of their backs and pelves fails to elicit distortion of normal alignment.

SUMMARY

1. A single stage operative method of management of chronically infected fractures with nonunion is considered.

2. The procedure which is performed during the quiescent stage, consists of an exacting excision of infected tissues to create a new vascular bed, followed by plate fixation for immobilization.

3. The progress of bone and soft tissue healing is favorably comparable to fresh-fracture healing.

4. Cessation of local infection and absence of dissemination are noted; the factor of latent infection is negligible.

5. The limb shortening is minimal and is compatible with normal activity and comfort.

6. The procedure hastens local and general rehabilitation and helps patients' morale.

THE SAPHENOUS VENOUS TRIBUTARIES AND RELATED STRUCTURES IN RELATION TO THE TECHNIQUE OF HIGH LIGATION

Based chiefly upon a study of 550 anatomical dissections

EDWARD H. DASELER, M.D., BARRY J. ANSON, Ph.D. (Med. Sci.),
ARTHUR F. REIMANN, M.D., and LINDSAY E. BEATON, M.D., Chicago, Illinois

RECENT medical literature contains many articles on the treatment of varicosities of the veins of the lower extremity. However, little has been written about the tributaries of the upper portion of the great saphenous vein, or about related fascial structures. Since attention is necessarily focused upon this area in the treatment of varicosities, knowledge of the commoner types of venous patterns and of variations in form and size of the fossa ovalis, should be of service to the surgeon.

The present account deals with vascular varieties, to include the following superficial veins: iliac circumflex, external pudendal, epigastric, lateral and medial accessory saphenous veins. In addition, the observations have to do with the fossa ovalis and its contained femoral vessels, with the overlying and surrounding fascial layers and with some recommended features of surgical technique which are, in the main, based upon the anatomical aspects of the study.

MATERIAL AND METHODS

All anatomical observations were made on dissection-room specimens (American whites and negroes, preponderantly male). The observations on fascial layers were made concurrently with those on the blood vessels, covering 350 consecutive body-halves. The statements on form and size of the fossa ovalis and on the relations of the femoral vessels are taken from an earlier investigation covering 200 consecutive lower extremities (Anson and McVay, 1938); those on structure of the femoral sheath are based upon a study of the anatomy of femoral hernia (in preparation; Anson, Ashley, Reimann and Beaton).

A sketch of the subcutaneous veins of the inguinofemoral region in each of the 350 thighs was prepared. Accessory venous tributaries entering the great saphenous vein more than 6 centimeters below the junction with the femoral were not considered. In selecting the anatomic types of venous convergence upon the main saphenous vessel, those records represented the specimens; types, therefore, were not selected early in the study from a limited group, and then set up as categories into which later cases were fitted.

The illustrations in Figure 2 are diagrammatic, the distance between tributaries and the caliber of the latter being arbitrary. Those in Figures 1, 3, and 4 represent actual specimens. The illustrations in Figure 5 are based upon e and g of Figure 3; ligatures are placed at points which, in the experience of the senior author, would have been selected in actual surgery of the case.

OBSERVATIONS AND DISCUSSION

1. ANATOMY

The anatomical material will be presented in the order in which the sets of layers or groups of vessels are encountered in dissection; first will be considered the superficial fascia, next the superficial veins, finally, the deep fascia with its fossa ovalis and the contained femoral vessels.

a. *Superficial fascia.* Over the proximal third of the thigh, in the area of the femoral triangle, the superficial fascia is two-layered, just as it regularly is in the adjacent inguinal and perineal regions (McVay and Anson, 1938 and 1940). The outer, superficial layer

Contribution No. 435, from the Anatomical Laboratory, Northwestern University Medical School.

TABLE I.

Type	Right	Left	Bilateral	Per Cent
I	28	24	5	14.86
II	31	22	10	15.14
III	25	21	2	13.14
IV	10	11	2	6.00
V	13	14	3	7.71
VI	60	57	19	33.43
VII	4	3	0	2.00
VIII	9	18	5	7.71
Totals	180	170		

of the bilaminar superficial fascia is a fatty stratum, while the inner, deep layer is fibrous; the latter contributes to the formation of a strong membranous investment for the larger vessels of the thigh. It is rather readily separable from the outer adipose layer (Fig. 1, a and b). In addition to the superficial veins, the subinguinal and inguinal lymph glands are situated in this deep membranous stratum, which, in the femoral triangle, sometimes contains an appreciable deposit of fat. When followed into the fossa ovalis, and therefrom proximalward under the inguinal ligament, the fibrous lamina is found to become the femoral sheath (Fig. 1, c and d). At the inguinal ligament it is continuous with the plate of non-fatty tissue which houses the iliac vessels and with the fascial coverings of the abdominal aponeuroses.

In this way the femoral vessels are protected as they lie within the fossa below the level of the falciform margin; the saphenous and its tributaries are nearer the skin, yet course along the fascia lata where they are lodged in the fibrous layer of superficial fascia and covered by the fatty stratum.

b. *Superficial veins.* Before presenting original observations on the saphenous tributaries, it will be helpful to review briefly the standard descriptions of these channels.

The superficial circumflex iliac vein is regularly described as a small, but quite constant, vessel which drains the area superior to the lateral half of the inguinal ligament and as far lateralward as the anterior superior spine of the ilium. It is said to be only occasionally duplicated. The vein courses inferomedially, crossing the inguinal ligament obliquely en route to the fossa ovalis, where it may terminate in the great saphenous, the femoral, the superficial epigastric, or the lateral accessory saphenous vein.

The superficial epigastric vein is likewise small. Arising in the umbilical region, sometimes through anastomosis with the thoracoepigastric vein, the vessel courses inferolaterally, over the medial half of the inguinal ligament to the fossa ovalis. Here it empties into the saphenous vein, into any one of the latter's tributaries, or into the femoral directly. It may anastomose across the linea alba, with the companion vessel of the opposite side, or may communicate with the dorsal penile vein.

The external pudendal is a continuation of the anterior scrotal or labial veins; it commonly receives communications from dorsal penile or clitoridal vein and from vessels of the hypogastric region. At the fossa ovalis the pudendal may empty into the great saphenous vein or the femoral, or any near tributary (superficial epigastric or accessory saphenous).

Exceeding the above mentioned vessels in size, is a vein which is sometimes termed lateral accessory saphenous. This vessel, quite constant in occurrence, originates in a suprapatellar network, gathering branches from the anterior and lateral surfaces of the thigh. It inclines medially in ascending to the fossa ovalis, where it is likely to empty into the superficial circumflex iliac vein or into the great saphenous vein.[1]

The medial accessory saphenous vein is by far the least constant of the proximal femoral group. It drains the posteromedial surface of the thigh and is directed anterosuperiorly, to terminate in the great saphenous vein. When such an accessory vessel ascends into the proximal one-fifth of the thigh, it usually receives the external pudendal vein near its terminus.[2]

[1]This vessel has been previously described by numerous investigators under the names of external superficial femoral vein (Piersol), lateral superficial femoral vein and lateral femoral circumflex vein (Cunningham), accessory saphenous vein (Tandler), and anterior saphenous vein (Poirier and Charpy).

[2]In the BNA terminology, this vein is merely termed the accessory saphenous vein; however, the additional designation, medial, seems requisite to distinguish it from the accessory vessel of the opposite aspect of the thigh. Other terms designating this vessel are: internal femoral cutaneous vein (Toldt); medial superficial femoral vein, medial circumflex femoral vein (Cunningham); posterior saphenous vein (Poirier and Charpy).

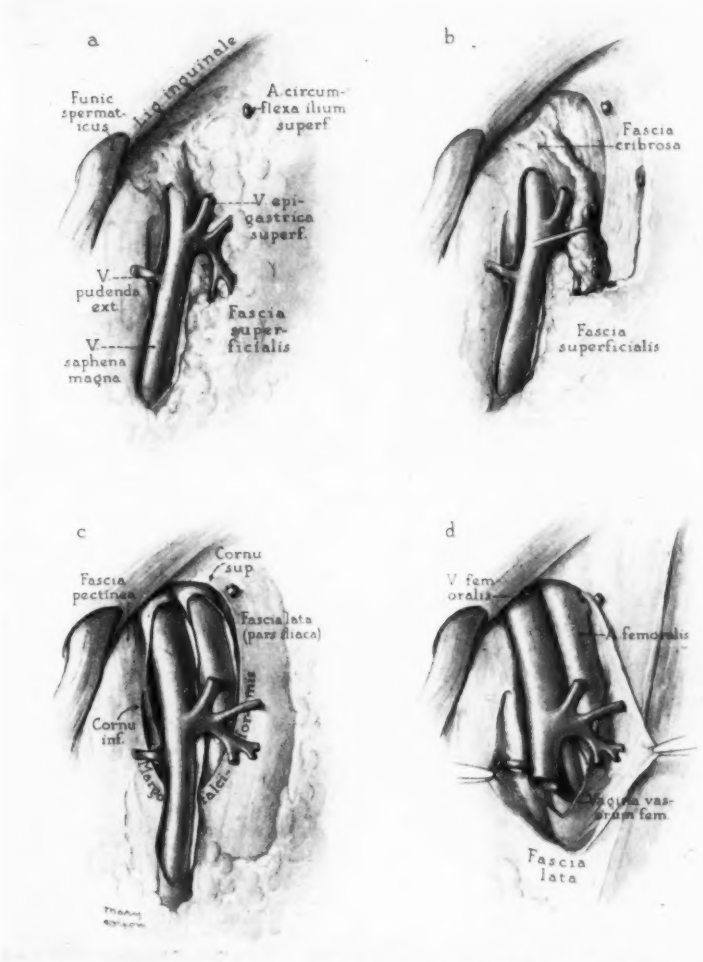


Fig. 1. Investments of saphenous and femoral veins, successive stages of dissection from superficial fascia (a and b) to fascia lata and femoral sheath (c and d). In Figure 1a, fatty layer of superficial fascia has been removed at fossa ovalis to expose membranous layer where it ensheaths saphenous vein. Figure 1b, fatty layer reflected from area lateral to fossa to show falciform margin and superior cornu; adipose layer is perforated by saphenous tributaries to form fascia cribrosa, and is continuous with similar tissue in depths of fossa. Figure 1c, fatty layer entirely removed to demonstrate manner in which immediately subjacent deep layer of fascia forms a complete sheath (here opened) for femoral vessels. Figure 1d, sheath further exposed by cutting it beneath incised distal edge of falciform margin.

While such descriptions account for common anatomical features, they leave unrecorded some important details of morphology and incidence of common departures from the anatomic normal. These data will now be presented from the authors' observations.

The patterns formed by the five major tributaries of the proximal part of the great saphenous vein are numerous. There is, however, a marked tendency for two or more of these vessels to fuse into a common venous trunk before entering the great saphenous vein.

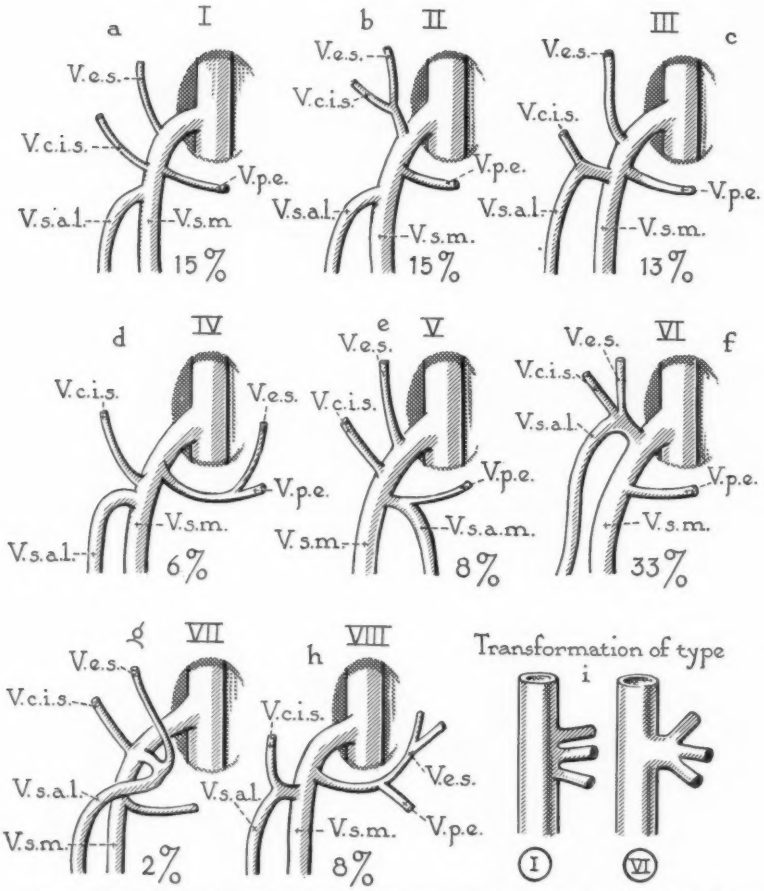


Fig. 2. Diagrams of saphenous tributary patterns. All shown as of right thigh. Types (8) indicated by Roman numerals. Percentage occurrence, in 350 consecutive specimens, recorded. Abbreviations for veins: *V.c.i.s.*, vena circumflexa iliaca superficialis; *V.e.s.*, vena epigastrica superficialis; *V.p.e.*, vena pudenda externa; *V.s.a.l.*, vena saphena accessoria lateralis; *V.s.a.m.*, vena saphena accessoria medialis; *V.s.m.*, vena saphena magna. Figure 2i indicates manner of change of tributaries, from separate entry (I) to common trunk (VI), through lateral protrusion of area of convergence.

The simplest pattern, designated type I, is that in which each tributary empties separately into the great saphenous vein (Fig. 2a). This arrangement occurs in 15 per cent of cases (52 of 350; 28 on the right, 24 on the left side, bilaterally in 5).[1]

In type II, the two abdominal tributaries, namely, the superficial epigastric and superficial circumflex iliac veins, join to form a single trunk draining into the great saphenous vein (Fig. 2b). The incidence of this vascular pattern is 15.1 per cent (53 cases; 31 right, 22 left, 10 bilateral).

Type III includes those cases in which the two lateral tributaries, namely, the superficial circumflex iliac and lateral accessory

[1]In this group the bilateral set includes 10 thighs of the 52; thus, 23 of the right side were unilaterally of type I, as were 19 of the left. Succeeding distributions, recorded parenthetically, are similarly arranged. In the text and in the table incidence is recorded to fraction of one per cent, but in figure 2 fractional parts of one per cent are omitted.

saphenous veins, are confluent (Fig. 2c); the incidence of this arrangement is 13.1 per cent (46 cases; 25 right, 21 left, 2 bilateral).

In type IV the two regular medial veins, namely, superficial epigastric and superficial external pudendal veins, fuse before entering the great saphenous vein (Fig. 2d); incidence, 6 per cent (21 cases; 10 right, 11 left, 2 bilateral). This vascular pattern occurs frequently in association with fusion of the two lateral branches (superficial circumflex iliac and lateral accessory saphenous veins); the combination is catalogued as type VIII.

Type V includes cases in which an accessory medial saphenous empties in common with the external pudendal vein into the great saphenous vein (Fig. 2c); incidence, 7.7 per cent, (27 cases; 13 right, 14 left, 3 bilateral). In a few instances the medial accessory vessel is present with one or the other of the remaining types, but so rarely that elevation to the status of a separate type is not warranted. A lateral accessory saphenous vein only rarely accompanies a medial accessory saphenous (2 in the 27 cases). This would suggest that when a medial accessory vessel is present, the lower femoral tributaries of the great saphenous vein drain the region usually cared for by the lateral accessory vessel.[1]

Specimens designated as type VI are characterized by a fusion of the three lateral tributaries, namely, the epigastric, circumflex iliac, and lateral accessory saphenous; the single vein thus formed drains into the great saphenous. This pattern is, by far, the commonest encountered in the current study (Fig. 2f); incidence, 33.4 per cent (117 cases; 60 right, 57 left, 19 bilateral).

In specimens of type VII an unusual plan of fusion occurs; the superficial epigastric and the lateral accessory saphenous veins join over the fossa ovalis to terminate by a common stem in the great saphenous vein, while the circumflex iliac vein and pudendal veins end independently in the main venous trunk (Fig. 2g); incidence, 2.0 per cent (7 specimens; 4 right, 3 left, none bilateral).

In type VIII dual fusion takes place; the circumflex iliac and lateral accessory saphenous veins on the one side, and the external pudendal and epigastric veins on the other, form lateral and medial common tributaries, respectively (Fig. 2h); incidence, 7.7 per cent, (27 cases; 9 right, 18 left, 5 bilateral).

Viewing the specimens as a group, some additional facts are evident. The tributary most frequently duplicated is the external pudendal vein (54 instances in 350 thighs); however, triplication is rare (2 cases). The next most frequent duplication is that of the superficial circumflex iliac vein which occurs in 4.8 per cent of thighs (17 cases); in over half of these the supernumerary vessel empties into the femoral vein directly. The circumflex iliac is tripled in but one instance. Termination as a single vessel in the femoral vein occurs in 1.7 per cent of specimens (6 cases). The superficial epigastric vein is infrequently doubled, the arrangement occurs in only 3.1 per cent (11 cases); it is never tripled, and is absent in only 1.4 per cent (5 cases). The lateral accessory saphenous vein is duplicated in approximately the same number of cases (10), never present in triplicate.[2]

The actual specimens, upon which the diagrammatic figures (Fig. 2a to 2h) are based, present some details of form which require special consideration. Small veins from nearby lymphatic glands are common (at asterisks, Fig. 3). Not infrequently tributaries enter the saphenous through a bay-like "trunk" as an intermediary (Fig. 3a), so that the confluence may be regarded as formed by two tributaries (type II) or by three (type VI). In the present study vessels were considered to empty separately if their common trunk measured less than 2 millimeters in length. Transformation readily occurs when the "bay" is widened (type I into type VI, Fig. 2i). Surgically the distinction is unim-

[1] Usually the great saphenous vein divides lower in the leg or receives small branches lower in the leg from the region drained by the medial accessory saphenous vein.

[2] The division made by Poirier and Charpy of the superficial epigastric vein into "satellite veins" (which ascend directly with the small artery of the same name) and "accessory veins" (are associated with the external pudendal vein) was investigated. Employing as criterion simply the simultaneous occurrence of both vessels on one side, the arrangement is found to be quite common (38 per cent; 132 in 350 thighs.)

The lateral accessory saphenous vein, which occurs commonly in the present authors' series, is not listed in the BNA terminology; however, in the literature it has been described under a variety of names. Edwards (1934) has pointed out the importance of this lateral vessel from a clinical standpoint.

The lateral superficial connections of the dorsal superficial vein of the penis do not alter the present scheme of typing. When such a connection exists, it is by way of either a single or double external pudendal vein or by way of a medially displaced superficial epigastric vein. It has its main connections with the left side as was brought out by Gras (quoted by Poirier and Charpy).

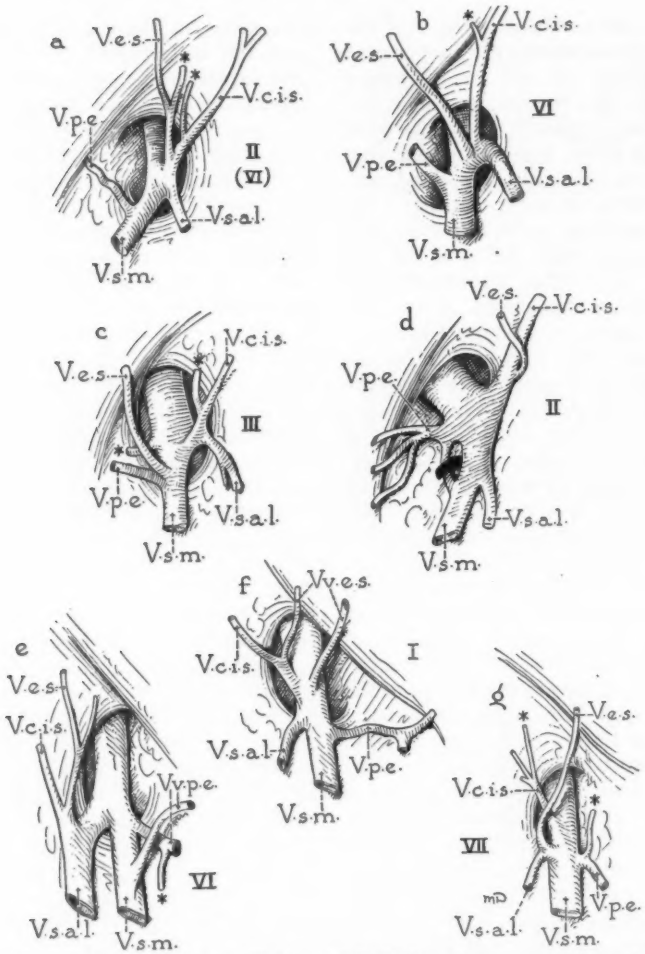


Fig. 3. Actual specimens. Right and left thighs. From comparable specimens diagrammatic Figures 2a to 2i were prepared. Asterisks indicate small veins draining lymph glands (glands removed; arteries omitted).

portant, since the tributaries in either case would require separate ligation, the side-channel being so capacious that tearing would result were the common trunk enclosed in a single ligature.

When the accessory saphenous vein follows an arching course en route to the great saphenous, then descending veins seem to be tributaries of the accessory, rather than two of a triad of tributaries of the main saphenous vein (Fig. 3b). The accessory may be almost as large as the main vein (Fig. 3b) or much the smaller of the two.

While ordinarily the descending veins from the inguinal wall (epigastric and iliac) are small and of approximately equal size (Figs. 3c to 3e and Fig. 3g), occasionally one of them may be almost as prominent as the great saphenous (Fig. 3d), the two of them lying in a straight line. Occasionally, a hiatus for transmission of an artery occurs in a broad vein, in an area where tributaries are re-

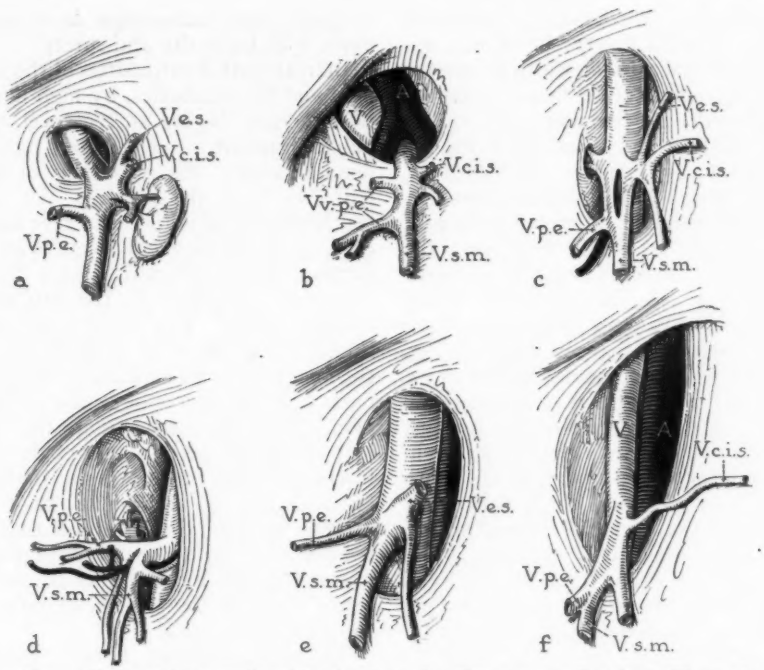


Fig. 4. Types of fossa ovalis, with related vessels. Figure 4a, smallest fossa; Figure 4b, small circular fossa, with femoral artery fully exposed; Figures 4c and 4d, large oval fossa, with femoral artery concealed and femoral vein wholly or partially exposed, saphenous vein receiving deep tributaries within fossa; Figure 4e, large oval fossa, with lateral half of artery concealed by falciform margin; Figure 4f, largest fossa (in 200), with artery fully exposed. Adapted from Anson and McVay, 1938.

ceived (Fig. 3d). These may be received proximally rather than distally, with the result that several veins from a region converge upon a short trunk (Fig. 3d). When a vein drains one area chiefly, but closely skirts another, it may receive a tributary from the latter; for example, an extra epigastric may enter the circumflex iliac (Fig. 3e). Almost always the accessory saphenous veins are much smaller than the great saphenous. With similar degree of constancy tributaries empty into the saphenous (separately or by conjoined trunk) on their own side of the chief vessel. Rarely, however, the superficial epigastric crosses to the lateral side to end on the opposite aspect of the saphenous (Fig. 3g).

It is important, surgically, to know over how great a length of the saphenous vein tributaries of the proximal group will enter the main channel. In a consecutive series, the distance from the termination of the femoral to the most distally placed tributary was 1 centimeter or less in 15 per cent of cases, 1.1 to 1.5 centimeters in 26 per cent, 1.6 to 2 in 24.5 per cent, 2.1 to 2.5 in 16 per cent, 2.6 to 3 centimeters in 9 per cent, 3.1 to 3.5 centimeters in 5.5 per cent, 3.6 to 4 centimeters in 3 per cent, and over 4 centimeters in only 1 per cent. This means that in the great majority of cases (96 per cent) the tributaries are received by the saphenous vein in the last 3.5 centimeters of its length, close to, or directly over the fossa ovalis.

c. *Fossa ovalis and femoral vessels.* The fossa ovalis is regularly pictured as an elongated fault in the fascia lata situated just distal to the inguinal ligament, and as being considerably larger than required for transmission of the saphenous vein. In some illustrations in standard textbooks, the falci-

form margin is shown extending lateralward to cover the femoral artery; in others, approximately half the artery's width is exposed beyond the free margin of the fossa. Actually, both arrangements are common.

In an earlier study, conducted in the authors' laboratory (Anson and McVay, 1938) on 200 thighs, the smallest fossa encountered measured 1.6 centimeters in length, and was circular in form (Fig. 4a); the largest was 8.5 centimeters long and 3.5 centimeters wide (Fig. 4f). In 90 per cent of the specimens the length was between 3 centimeters (Fig. 4b) and 6.4 centimeters (Fig. 4e); the average length was 4.6 centimeters. In 87 per cent the width was between 3.9 centimeters and 1.5 centimeters; the average width was 2.8 centimeters. The femoral vein was found to be exposed through its full width in virtually every specimen. In 83 per cent of 100 consecutive specimens the femoral artery, also, was wholly or partially exposed. More specifically, in 36 per cent three-fourths to all of its width was in view (Fig. 4f); in 30 per cent, one-half to one-fourth (Fig. 4e); not infrequently (17 per cent) the artery was fully exposed, with space remaining between the vessel and the margin of the fossa (Fig. 4b). In some cases venous tributaries were found to come forward through the fascial floor of the fossa to empty into one of the lesser tributaries or into the saphenous itself (Figs. 4c and 4d).

2. SURGERY

It is established beyond threat of denial that a surgical technique is best when it pays greatest heed to the normal fabrication of the human body. By the same token it is true that refinement of anatomic concepts of structure makes for less disturbing surgery. When a particular method depends heavily upon anatomical descriptions and figures of stereotyped order—such as are found in standard textbooks—the possibility of technical improvement is decreased, and the surgeon's feeling of security is, as a consequence, lowered. But when, on the contrary, the surgeon is armed with detailed foreknowledge of common variation in structural pattern and has access to actual pictorial records of paramount features in their most frequent interrelationships, he is equipped to move with ingenuity and surety.

In treatment of varicosities of the saphenous vein and its tributaries, by high ligation, the skin incision begins at the level of the inguinal ligament 2.5 centimeters medial to the femoral artery, the pulsations of which are palpable from the surface. An incision 5 centimeters long is found to give satisfactory exposure of the saphenous vein in its proximal portion, where tributaries reach the areas of "torcular" junction of the saphenous and femoral veins.[1] The incision should incline slightly medialward as it descends, to match the long axis of the saphenous vein, which departs from the less oblique one of the femoral vein. As mentioned earlier, the saphenous vein lies in the deeper layer of the superficial fascia. The chief tributaries are lodged in this layer, as are also the lymph glands and their arteries of femoral source and their veins of femoral or saphenous termination. This means that the incision may be carried quite safely through the superficial fatty layer of the superficial fascia.

The saphenous vein is next freed from its fibrous covering of fascia, from the point of entrance into femoral downward for a distance of 3 centimeters or more. It is readily distinguished from the femoral vein, since the latter lies not only subjacent to the saphenous, but under the superior and inferior margins of the fossa ovalis, in which situation it is invested by a fairly heavy prolongation of the femoral sheath. The stripped length of 3 centimeters is almost always sufficient to expose all of the converging tributaries; in the present authors' studies it was found that the area of reception of tributary veins rarely exceeded that length.

Since any or all of these tributaries may open into the broadened saphenous at its junction with the femoral, the confluence is then, to all intents and purpose, with the femoral itself. From the surgical standpoint this means that it is unsafe to ligate the saphenous only; the tributaries should be

[1] In this and in succeeding parts of the discussion the account of technique has been adapted from Ochsner and Mahorner's excellent monograph; the elaborations on anatomy are the joint contributions of the several co-authors of the present article, while the surgical notes are based upon observations made by the senior author, Dr. E. H. Daseler.

ligated separately (Fig. 5). At first sight it might be considered satisfactory to ligate the confluent channel (cf. Fig. 2i). Actually, however, such a procedure would be venturesome, since the channel, being short, might not retain a ligature after excision of a segment of the great saphenous vein (see hereinafter). All of the tributaries of the saphenous should be ligated, since unligated veins, even when small, are likely to bring on recurrence of the varicosities, especially in the case of the lateral accessory branch. It is worth recording that several cases have been observed in which large lateral accessory branches have been mistaken for the great saphenous vein and ligated in its stead; and that lateral accessory saphenous branches which are equal to or larger than the great saphenous trunk are not uncommon.

In mobilizing the saphenous vein and its satellites it is advisable to free the vessel somewhat from its ensheathing tissue proximalward, to its point of junction with the femoral, in order to be certain of the position of the latter. Failure to make adequate exposure, in a case recently observed, led to misidentification of the femoral vein; mistaken for the great saphenous, the femoral was ligated and severed.

It is important to realize that varicose dilatation of a tributary may simulate hernial enlargement, when the swelling lies over or near the fossa ovalis. One of the authors has seen a case in which enlargement of the superficial circumflex iliac vein was incorrectly diagnosed as a femoral hernia.

Regardless of whether the tributaries be closely grouped in turcular fashion or segregated, a segment of the saphenous trunk should be removed (between proximal and distal ligatures) to render improbable regeneration and re-establishment of vascular connections (Fig. 5). Simple ligation, without severance of the saphenous vein or of its tributaries is likely to result in recurrence of varicosities. The proximal ligature should be placed as near the point of emptying of saphenous into femoral as is technically possible. When a long proximal stump of the saphenous remains, the possibility of thrombosis, with subsequent embolism, is greatly increased.

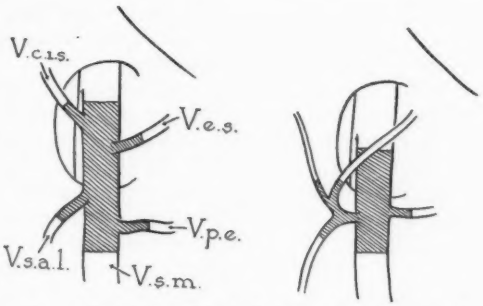


Fig. 5. Technique of high ligation of saphenous vein and tributaries; two patterns of venous pattern shown. Stippled area indicated segment to be removed after ligation.

Removal of a segment of the saphenous is the only dependable way of providing a "substitution-valve" in the territory of the saphenofemoral junction. Because varicosities in the saphenous system are the result chiefly of valvular incompetence at the saphenofemoral junction, ligation of proximal tributaries only, would bring relatively slight hydrostatic relief to the main recipient vein (i.e., saphenous). But, when the saphenous (with its weakened valves) is ligated and cut, recurrence is obviated; the most troublesome segment has been extirpated, and the vascular stream has been strongly diverted through numerous lesser channels whose structure is less impaired.

Several additional anatomical features require practical consideration. These are the regular presence of branches of the femoral artery in and near the fossa ovalis, the exposure of the femoral artery itself within widely open fossae, the occurrence of communicating veins from deep (muscular) level, and of veins received from lymphatic glands.

The arteries referred to are those for which the veins herein considered serve as *venae comites*. Usually they match each other in course. Sometimes, however, the arteries pass beneath the saphenous en route to their areas of inguinal, femoral, or pudendal supply, or emerge through lesser hiatuses in the falciform margin of the fossa ovalis being, thus, unpredictable in position. This feature, coupled with the fact that they are occasionally large, makes it advisable to exercise care

in mobilizing the tributary veins where they reach the fossa. Transection of the arteries could cause troublesome bleeding.

While the femoral artery is more likely to be beneath the deep fascia at the falciform margin than to be exposed medial to the latter's free edge, instances are not uncommon in which the latter arrangement obtains (Fig. 4). In rare instances the artery is exposed in full width, and for a length of 8 centimeters or more. Although fossae tend to be wide when they are long, and hence assume an oval outline, exceptional width may be exhibited by fossae of ordinary length—so that the femoral artery lies unguarded in a circular fossa.

It is well known that communications with veins of muscular level occur at variable intervals along the entire course of the greater and lesser saphenous veins; they pass through small hiatuses in the pedal, crural, and femoral portions of the deep fascial investment of the lower extremity. It is not generally recognized, however, that vessels of communicating type may occur within the confines of the fossa ovalis. Such vessels emerge through the pectineal fascia on the floor of the fossa, to terminate quickly in the saphenous vein (Fig. 4c and 4d) or in the femoral. In "anchoring" the saphenous to subjacent veins they render mobilization of the vessels more difficult.

Veins draining the lymph glands of the inguinal and subinguinal groups are regularly of dissectable size, and occasionally as large as the epigastric and circumflex iliac veins (Fig. 4a). They could cause troublesome bleeding were they inadvertently cut and left unligated. The same would apply to transection of the companion arterial branches from the femoral.

Conclusions

In a study of the subcutaneous veins tributary to the great saphenous vein at or near the latter's termination in the fossa ovalis, it was found that vascular patterns (from 350 thighs) could be arranged in eight general types, according to the degree of complexity and of tributary fusion. Fusion of two adjacent tributaries entering one side of the saphenous vein occurs very frequently; fusion to produce a common trunk on each of the two sides in the same specimen is uncommon, as is also independent termination of all tributaries. However, no matter whether conjunction or separateness obtains, the tributaries enter the saphenous vein over the area of, or just distal to the lower margin of the fossa ovalis; in more than half of the cases they enter the saphenous in its upper 2 centimeters, and rarely over an area greater than 3.5 centimeters in length (measured downward from the femoral termination of the saphenous). These observations mean, surgically, that the area of required exposure of the saphenous vein need not be extensive; a length of approximately 4 centimeters would be more than adequate in most instances. Width of the area would be governed by the type of tributary pattern revealed in tracing the veins peripheralward from their terminations.

These venous channels from abdomen, perineum, and thigh are lodged in heavy fibrous tissue which lies just external to the deep fascial investment (fascia lata) of the musculature of the thigh; only their lesser tributaries course through the fatty pannicle from subcutaneous level. As the larger veins (epigastric, pudendal, etc.) approach the saphenous, the fibrous tissue forms for them a grossly demonstrable coat, which, traced with them into the fossa ovalis, becomes the strong femoral sheath. This sheath is actually bilaminar, its outer lamella being a prolongation, under the inguinal ligament, of the tranversalis and iliac fasciae, its inner lamella being a similar derivative of the heavy fibrous layer of retroperitoneal tissue. The main venous tributaries of the saphenous thus lie next to the fascia lata, their depth below cutaneous level increasing with obesity of the subject. The femoral vein is situated on the floor of the fossa, upon the fascia covering the pectineus muscle; its free (anterior) surface is flush with the plane of iliac (lateral) portion of the fascia lata, where the latter forms the falciform margin of the fossa. This is tantamount to saying that, from the surgical standpoint, the veins which come into the field of varicosity ligation are predictably located in relation to fascial planes, and, to some extent, protected from inadvertent transection. The femoral artery in more than

three-fourths of cases, is exposed within the fossa (i.e., extends medially beyond the falciform margin) for part or all of its width—a circumstance which requires care in dissecting down upon the adjacent femoral vein.

The regular occurrence of iliac, epigastric, and pudendal branches of the femoral artery and the occasional presence of intrafossal venous tributaries, from muscular sources, are additional anatomical features which increase the need for surgical caution.

REFERENCES

1. ANSON, B. J., and MCVAY, C. B. Anat. Rec., 1938, 72: 399-404.
2. EDWARDS, E. A. Surg. Gyn. Obst., 1934, 59: 916-928.
3. MAHORNER, H. R., and OCHSNER, A. Ann. Surg., 1938, 107: 927.
4. MCVAY, C. B., and ANSON, B. J. Anat. Rec., 1938, 71: 401-407.
5. Ibid., 1940, 76: 213-231.
6. OCHSNER, A., and MAHORNER, H. R. Varicose Veins. St. Louis: C. V. Mosby & Co., 1939.
7. PIERSOL, H. Human Anatomy. Philadelphia and London: J. B. Lippincott Co., 1913.
8. POIRIER, P., and CHARPY, A. Traité d'anatomie humaine, Par., 1920, Vol. 2, pt. 3.
9. ROBINSON, A. (edited by) Cunningham's Textbook of Anatomy. 5th ed. New York: William Wood & Co., 1926.
10. TANDLER, H. Lehrbuch der systematischen Anatomie. Leipzig: Vogel, 1919.
11. TOLDT, C. An Atlas of Human Anatomy. Edited by D. E. Paul. New York: Rebman, 1919.

THORACOABDOMINAL WOUNDS

A Review of 270 Cases

DENNIS B. FOX, M.D., Captain, M.C., A.U.S., Randleman, North Carolina

THIS report is a review of patients with thoracoabdominal wounds admitted to a General Hospital in Italy between November 16, 1943, and February 28, 1945. The data were obtained from a survey of the total admissions of American or Allied troops. During this period 270 patients were admitted with the diagnosis of one or more perforations of the diaphragm. This number represents an incidence of 1 per cent of the total of 26,852 patients admitted, and 1.9 per cent of the total of 14,112 patients who were either battle casualties or injuries. The report does not include a rather large number of patients who had separate penetrating wounds of the abdomen or chest. It reviews only those patients who had a perforation of the diaphragm by a metallic foreign body.

Between April 1, 1944, and December 20, 1944, this hospital functioned as an active chest center. During this period there were exactly 1,000 patients admitted to the chest service. One hundred and eighty-two, 18.2 per cent, of these patients, so called "chest cases," had thoracoabdominal injuries.

All patients in this series were white males except one, a negro. Their average age was in the low twenties.

Fifty-two cases, 19.3 per cent, were due to machine gun or gunshot wounds, and 218, 80.7 per cent, were due to shell fragments.

The report will be discussed under the following division: (1) type and incidence of traumatic lesions, (2) therapy in forward hospitals, (3) therapy in the general hospital (4) complications, (5) results and disposition of patients, and (6) summary.

TYPE AND INCIDENCE OF TRAUMATIC LESIONS

Few thoracic and abdominal organs are immune to injury in penetrating or perforating thoracoabdominal wounds. In this series, the adrenals and bladder are the only organs which were not injured. Table I shows the variety and incidence of the various thoracoabdominal lesions and the more serious of the concomitant lesions sustained by the patients. Only 48.5 per cent of the patients had pneumothorax, hemothorax, or hemopneumothorax. It is believed that the actual incidence was higher, but the degree was so mild that the condition was not listed as a diagnosis.

THERAPY IN FORWARD HOSPITALS

The possibility that a bullet or shell fragment may have perforated either the thoracic cavity or abdominal cavity or both is the problem that presents itself with each patient who sustains an injury to the chest or abdomen, particularly the lower chest. It requires skillful surgical judgment in the early evaluation of the lesions in these patients, and no less skill in the proper operative treatment. In penetrating, as well as perforating, tangential wounds, the surgeon must choose between an exploratory laparotomy, thoracotomy, thoracotomy with transdiaphragmatic abdominal exploration, a separate thoracotomy and laparotomy, or a simple débridement of the wound. That no one approach has found universal favor is shown by reference to Table II. One patient had a left thoracotomy, a laparotomy, and a right thoracotomy at his initial operation.

X-ray films in suspected thoracoabdominal injuries may be misleading, particularly if the plate is underexposed, if read when wet and by an inadequate light. Under these conditions small intra-abdominal foreign bodies may be overlooked. Early clinical signs may also be mild or be masked by other injuries such as brain or spinal cord lesions, burns, severe fractures, and similar injuries. It is to the credit of the surgeons in the forward hospitals, therefore, that only 5 of the 270 pa-

From Surgical Service, 300th General Hospital.

TABLE I.—TYPE AND INCIDENCE OF TRAUMATIC LESIONS

Type of lesion	Cases	Per cent
Thoracoabdominal Lesions		
Perforation of right diaphragm	159	58.9
Perforation of left diaphragm	107	39.6
Perforation of right and left diaphragm	4	1.5
Perforation or laceration or both of lung	92	34.0
Pneumothorax, hemothorax, or hemopneumothorax	131	48.5
Retained foreign body in lung	10	3.7
Perforation or laceration or both of right lobe liver	138	51.1
Perforation or laceration or both of left lobe liver	17	6.3
Total cases of liver injury	155	57.4
Retained foreign body in liver	13	4.8
Perforation or laceration or both of spleen	62	23.0
Perforation or laceration or both of right kidney	19	7.0
Perforation or laceration or both of left kidney	17	6.3
Total cases kidney injury	36	13.3
Laceration renal artery	1	0.4
Perforation or laceration or both of stomach	35	13.0
Laceration of colon	15	5.6
Laceration small bowel	11	4.0
Laceration pancreas	4	1.5
Laceration gall bladder	2	0.7
Laceration pericardium	5	1.9
Laceration heart	3	1.1
Concomitant Lesions		
Compound fractures, other than ribs	42	15.6
Peripheral nerve palsy	15	5.6
Spinal cord injury	4	1.5
Brain injury	3	1.1
Amputations	5	1.9
Burns, second and third degree	1	0.4
Laceration right common iliac vein	1	0.4

TABLE II.—PRIMARY OPERATIONS AT FORWARD HOSPITALS

Operations	Cases	Per cent
Thoracotomy	70	28.2
Laparotomy	62	25.0
Thoracotomy with transdiaphragmatic abdominal exploration	59	23.8
Débridement of wounds, only procedure	29	11.7
Laparotomy and thoracotomy	23	9.3
No surgery	5	2.0
Total	248	100.0
(No record available as to type of operation)	22	
Total	270	

tients with thoracoabdominal injuries were evacuated to the base hospital without the presence of thoracoabdominal injury having been recognized and without any operation having been done. These patients were evacuated during periods of extreme activity on the front, at which time large numbers of casualties were flooding the field and evacuation hospitals. Two of these patients were received within 24 hours after injury, so the time interval was not greatly in excess of that which would have elapsed had the patients had an operation in the forward hospitals. Two were received and operated upon 3 days after injury. Another had no immediate serious consequence of the wound and had no operation.

The variety of primary surgical procedures which were necessary is shown in Table III. The records showed only 60.5 per cent of the cases in which the diaphragm had been sutured. In only 1 case, however, was mention made that the diaphragm was *not* sutured. Similarly, only 9.7 per cent of the cases were reported to have closed intercostal catheter drainage of the pleural cavity following initial operation. Only one-half of the total number of patients having a wound of the liver had postoperative subcostal drainage of the liver or the subphrenic space.

Practically all of the patients received transfusions and plasma before and after the initial operation as well as sulfonamide, penicillin, or both. Records were not available as to the duration of therapy with these drugs. Sulfadiazine was the sulfonamide usually given and was administered in doses of 1 gram every 4 hours. Penicillin was given in the dosage of 25,000 units every 3 hours.

THERAPY IN THE GENERAL HOSPITAL

For the entire group of cases, the average time after injury until admission to this hospital was 18.9 days. The longest time interval was 129 days, the shortest 1 day.

It is interesting and very important to note that 43 per cent of the patients required no further operation at the base hospital. This does not mean that the patients did not require further therapy. On the contrary, many of the patients required a great deal of attention such as frequent thoracentesis, blood and plasma transfusions, dressing of wounds and colostomies, and changing of casts. The most frequent surgical procedure was wound closure. A total of 98 patients, 36.3 per cent, had secondary closure or secondary closures plus skin grafts. Thoracotomy for empyema was performed in 30 cases, 11.1 per cent. This pro-

TABLE III.—PRIMARY SURGICAL PROCEDURES PERFORMED AT FORWARD HOSPITALS

Surgical procedure	Cases	Per cent
Suture of diaphragm	150	60.5
Drainage of liver, subcostal	45	18.1
Packing of liver, gauze	24	9.7
Total cases with subphrenic or liver drainage	69	27.8
Suture of liver	7	2.8
Packing of liver with muscle	4	1.6
Splenectomy		
Transdiaphragmatic approach	33	13.3
Abdominal approach	10	4.0
Total splenectomies	43	17.3
Packing spleen with muscle	1	0.4
Suture stomach	28	11.3
Colostomy	14	5.7
Suture small bowel	4	1.6
Resection small bowel, partial	1	0.4
Nephrectomies:		
Right:		
1. Abdominal approach	3	1.2
2. Transdiaphragmatic approach	2	0.8
3. Renal approach	0	....
Left:		
1. Abdominal approach	2	0.8
2. Transdiaphragmatic approach	6	2.4
3. Renal approach	0	....
Total nephrectomies	13	5.2
Drainage of kidney	2	0.8
Suture of kidney	2	0.8
Suprapubic cystostomy	2	0.8
Ligation right common iliac vein	1	0.4
Suture of heart	1	0.4
Suture of lung	21	8.5
Intercostal catheter drainage	24	9.7
Partial lobectomy	2	0.8
Laminectomy	1	0.4

TABLE IV.—SECONDARY SURGICAL PROCEDURES AT FORWARD EVACUATION OR GENERAL HOSPITALS

Operations	Cases	Per cent
Secondary closure of wounds	17	6.9
Decortication:		
For empyema	5	2.0
Organizing hemothorax	3	1.2
Total decortications	8	3.2
Thoracotomy for empyema	7	2.8
Drainage for subphrenic abscess	6	2.4
Secondary closure of disrupted abdominal wound	1	0.4
Secondary thoracoabdominal exploration	1	0.4
Closure of colostomy	1	0.4
Phlebotomy, ligation of femoral vein	1	0.4

TABLE V.—SURGICAL PROCEDURES REQUIRED AT THE BASE HOSPITAL

Surgical procedure	Cases	Per cent
Initial, primary operation	4	1.4
No further surgery required	116	43.0
Secondary closure of wounds	85	31.5
Secondary closure with skin grafting	13	4.8
Thoracotomy for empyema	30	11.1
Thoracotomy for removal of foreign body	2	0.7
Thoracotomy, suture diaphragm, packing liver	1	0.4
Repair diaphragmatic hernia	1	0.4
Intercostal thoracotomy for tension pneumothorax	1	0.4
Decortication:		
Empyema	3	1.1
Organized hemothorax	2	0.7
Attempted decortication	1	0.4
Bronchoscopy for atelectasis	1	0.4
Exploratory laparotomy	5	1.9
Drainage or exploration or both, of subphrenic space	14	5.2
Drainage of liver abscess	1	0.4
Drainage of pelvic abscess	3	1.1
Closure of gastric fistula	1	0.4
Closure of colostomy	12	4.4
Nephrectomy	1	0.4
Removal of foreign body from eye	1	0.4
Amputation	1	0.4
Orthopedic procedures; skeletal traction, etc.	5	1.9
Drainage brain abscess	1	0.4

cedure usually consisted of a resection of a few inches of rib under local anesthesia and institution of closed drainage. A decortication of the lung was done in 3 cases for chronic empyema and also in 2 cases for organizing clotted hemothorax. An attempt was made to perform decortication of the lung in another case with chronic empyema but without success. There was an exploration of the subphrenic space in 14 patients, 5.2 per cent, and 11 of these had a subphrenic abscess which was drained. Table V shows the other procedures performed at this hospital.

Of the 5 patients admitted without previous operation, 4 had primary débridement and operation as follows: (1) thoracoabdominal exploration, splenectomy, suture of the diaphragm, débridement of wounds; (2) abdominal exploration, splenectomy, suture of diaphragm, débridement of wounds; (3) abdominal exploration, suture of jejunum, suture of diaphragm, colostomy, débridement of wounds; (4) débridement of wounds only.

COMPLICATIONS

Seven patients in this series died, which is a mortality rate of 2.6 per cent. A brief summary of these cases follows:

CASE 1. A white male, aged 22 years, was admitted 38 days after injury, in which he sustained a penetrating wound of the left thorax, with laceration of pleura, diaphragm, stomach, and spleen. He developed empyema of the left pleural space and an

embolic hemolytic staphylococcus brain abscess and died 9 days after admission, 47 days after injury.

CASE 2. A colored male, aged 25 years, was shot one day before admission to this hospital. He had a sucking wound of the right lower chest which was débrided and closed at a nearby station hospital. He was transferred to this hospital because of evidence of continued intrathoracic hemorrhage. On the day of admission to this hospital a thoracotomy was performed through the right eighth intercostal space, the liver was packed and drained subcostally, the diaphragm was closed, a bleeder in the pericardial fat was ligated, a laceration of the lung was sutured, intercostal underwater catheter drainage of the chest was established, and, following bronchoscopy, the patient returned to the ward in good condition. He had a sudden cessation of respiration approximately 30 minutes after returning to the ward and expired. No cause was found for his death.

CASE 3. A white male, aged 23 years, was admitted 10 days after his original injuries which consisted of a penetrating wound of the right thorax with a laceration of the lung, diaphragm, and liver. He also had a wound of the right hand with a fracture of the second metacarpal. At a forward hospital the primary treatment consisted of a thoracotomy with removal of the foreign body from the liver. A muscle transplant was placed in the liver laceration and the diaphragm was sutured. The pleural cavity was drained by catheter postoperatively. The patient ran high fever after admission to this hospital and expectorated bile-stained sputum and vomited bile several times. He was thought to have a subhepatic abscess, and operation for drainage was to be performed, but he died shortly after the anesthetic was started. Death occurred 19 days after injury. At autopsy he was found to have subphrenic and subhepatic abscesses as well as an abscess of the liver and a peritoneophrenicobronchial fistula. He also had a massive retroperitoneal hematoma, the cause of which was undetermined; a bronchopneumonia of the right lower lobe of the lung and dilatation of the right side of the heart.

CASE 4. A lieutenant, 24 years of age, was admitted 21 days after injury. He sustained multiple penetrating wounds of the right sternal region, with penetration of the right lobe of the liver, wounds of the left scalp, left arm, right thigh, and left shoulder. At forward hospitals he had had a débridement of his wounds, an exploratory laparotomy, and several days later drainage of a subphrenic abscess. At this hospital he had a secondary closure of his wounds and an exploratory laparotomy 45 days after injury with drainage of the subphrenic space. He developed multiple biliary fistulas of the abdominal wall and after a long, very stormy course finally expired 45 days after admission, 66 days after injury.

The principal autopsy findings were: multiple liver abscesses, subphrenic and subhepatic abscesses, bacteriemia due to Aerobacter aerogenes; peritonitis, acute; bile nephrosis; cholangitis, acute; empyema, right; bronchopneumonia, left; dilatation of the heart, severe; atelectasis of the right lower lobe of the lung; hyperplasia of the bone forming elements of the bone marrow.

CASE 5. A white male, aged 27 years, was admitted to this hospital 29 days after injury. He sustained a penetrating wound of the lower right chest with penetration of the right pleural cavity, diaphragm, and a laceration of the right lobe of the liver. The day following injury at a forward field hospital he had an exploratory laparotomy. A large wound of the liver was found and packed for a period of 10 days, after which the packing was removed. Shortly after the operation, the patient developed ascites and pitting edema of the ankles. He complained of an uncomfortable, full feeling in his abdomen and anorexia. Examination on admission to this hospital revealed signs of free fluid in the abdomen with edema of the ankles and toes. There was no evidence of collateral circulation. The liver was not palpable. X-ray examination of the chest showed some elevation of the left diaphragm. The patient ran a temperature in the vicinity of 99.4 degrees during his stay in the hospital. Six days after admission he was given 2 cubic centimeters of salyrgan and had a marked reduction in the size of the abdomen and moderate diminution of the edema of the feet. Seventeen days after admission the patient walked to the latrine, and, while having an apparently normal bowel movement, suddenly developed weakness, air hunger and cyanosis, and expired approximately 20 minutes later. Essential autopsy findings were: a massive subphrenic abscess, chronic, right, with terminal rupture into the peritoneal cavity; peritonitis, acute, diffuse, severe, terminal; atelectasis of lung, bilateral, due to compression; cardiac dilatation, marked, right.

CASE 6. A white male, aged 23 years, was admitted to this hospital 17 days after injury. He had received a penetrating wound of the left thorax, just below the nipple. The shell fragment passed through the pleural space, lacerated the apex of the pericardium, perforated the diaphragm, and lodged in the right lobe of the liver. Primary operation consisted of a laparotomy with suture of the diaphragm. The liver laceration was noted but there was no active bleeding. The foreign body was not removed. The chest wound was débrided and one suture was taken in the pericardium and the wound was closed. Four days after injury he began having chills and fever and was diagnosed as having malaria, though smears were negative. He was not acutely ill, and his condition was fairly good on admission. Shortly after admission, he began having almost daily chills and fever of 103-104.5 degrees F. Repeated malarial smears were negative. The patient became jaundiced and it was felt that he probably had a subphrenic abscess or a liver abscess or both. Two blood cultures were positive for Escherichia coli and two were negative. He did not improve with penicillin given in doses of 25,000 units every 3 hours or to heavy doses of sulfadiazine. Forty days after injury a first stage operation for exploration of the

TABLE VI.—COMPLICATIONS

	Cases	Per cent
Died	7	2.6
No thoracoabdominal complications	172	63.7
Chest complications		
Empyema	43	15.9
Bronchopleural fistula	4	1.4
Hemothorax, clotted, organizing	2	0.7
Atelectasis	4	1.4
Persistent large empyema cavity	1	0.4
Tension pneumothorax:		
Unilateral	1	0.4
Bilateral	1	0.4
Pleural effusion	1	0.4
Atypical 1 pneumonia	2	0.7
Bronchopneumonia	1	0.4
Pulmonary embolism, fatal	1	0.4
Pulmonary infarction	2	0.7
Pericarditis, acute, fibrinous	1	0.4
Abscess of thoracotomy wound	2	0.7
Abdominal complications		
Subphrenic abscess:		
Following previous subphrenic drainage	9	3.3
No previous drainage	8	3.0
Total subphrenic abscess	17	6.3
Liver abscess	3	1.1
Subhepatic abscess	1	0.4
Bile peritonitis	2	0.7
Pelvic abscess	3	1.1
Intestinal obstruction:		
From adhesions	1	0.4
Ileus	2	0.7
Abdominal biliary fistula	4	1.4
Biliary and urinary fistula	1	0.4
Gastric fistula	1	0.4
Hepatitis with jaundice	8	3.0
Spontaneous extrusion of gall bladder	1	0.4
Hematuria, cause undetermined	1	0.4
Albuminuria, cause undetermined	1	0.4
Hydronephrosis	1	0.4
Thoracoabdominal complications		
Phrenicopleurocutaneous fistula	8	3.0
Peritoneophrenicobronchial fistula	1	0.4
Diaphragmatic hernia	1	0.4
Miscellaneous complications		
Embolic brain abscess	1	0.4
Air embolism, cerebral, nonfatal	1	0.4
Septicemia, clostridial	1	0.4
Malaria, recurrent	1	0.4
Thrombophlebitis	3	1.1

right subphrenic space was done, and the second stage 10 days later, but no pus was found in the subphrenic space nor was any pus obtained with aspiration of the right lobe of the liver. In spite of tremendous quantities of blood and plasma, the patient's blood cells, hemoglobin, and serum protein remained low and he developed peripheral edema. This improved with the administration of human serum albumin daily in 100 cubic centimeter doses for 5 days, but the constant septicemia gradually debilitated the patient and he finally expired 50 days after admission, 67 days after injury. Autopsy revealed a small metallic foreign body in the right lobe of the liver which was lying partly within the lumen of a fairly large branch of the hepatic vein. There was a very small abscess cavity about the foreign body, and some abscess formation had occurred along the missile tract and had apparently recently ruptured into the abdominal cavity. Microscopically, the liver showed numerous minute abscesses.

CASE 7. A white male, aged 30 years, was admitted 9 days after having sustained a gunshot wound of the right shoulder which passed through the right thoracic cavity, lacerating the diaphragm and liver. He also had a wound of the right hip with an incomplete fracture of the greater trochanter of the femur. Original treatment consisted of débridement and suture of the thoracic wound, a laparotomy and suture of the diaphragm with subcostal drainage of the subphrenic space. Four days after admission he developed a tension pneumothorax on the right and the following day on the left and in spite of bilateral intercostal thoracotomies with catheter drainage the patient expired, 5 days after admission, 14 days after injury. Autopsy findings were: atelectasis, bilateral, marked; hydropneumothorax, right, moderate; cardiac dilatation, marked; abscess, subdiaphragmatic, right; congestion of viscera, marked; and extremity wounds, as described above.

Table VI shows that the most frequent complication was empyema. There were 43 cases of empyema, an incidence of 15.9 per cent of the 270 cases reviewed. There was only 1 case of empyema which did not have a perforation or laceration of some thoracic or abdominal organ. Of the 43 cases of empyema only 2, 4.9 per cent, were able to return to limited duty. The others were evacuated to the Zone of Interior for further convalescence. In only one case was there a large, persistent empyema cavity present when the patient was evacuated. The average number of days after injury until thoracotomy for empyema was done was 26.6. Only 2 cases of clotted, organizing hemothorax resulted from a total of 131 cases in which a diagnosis of hemothorax or hemopneumothorax was made. In the majority of the cases repeated thoracenteses were done and these were sufficient to cure the hemothorax entirely. It is interesting that clinically only 4 cases, 1.4 per cent, had atelectasis. This low incidence is probably due to the frequency of bronchoscopy following thoracic and thoracoabdominal operations. There were 17 cases, 6.3 per cent, who developed a subphrenic abscess, though the incidence in those cases with previous drainage and without previous drainage at the initial operation was practically the same. However, those patients who had subcostal drainage in liver injuries seemed to do better clinically than

TABLE VII.—DISPOSITION OF PATIENTS

Disposition	No. cases	Per cent	No. days A.I. until admission this hospital			No. days hospitalization at this hospital			No. days A.I. until disposition		
			Longest	Shortest	Average	Longest	Shortest	Average	Longest	Shortest	Average
Zone interior	150	55.5	129	1	31.9	181	5	45.5	215	22	77.5
Limited duty	82	30.4	72	2	16.2	131	18	58.3	159	27	74.6
Full duty	24	8.9	24	3	11.5	123	20	48.5	128	24	60.0
Evacuated to North Africa	7	2.6	25	11	17.0	26	2	10.1	39	17	27.1
Died	7	2.6	38	1	17.9	50	1	23.6	75	2	41.4

Total—270 100.0 A.I.—After Injury.

did those who had no drainage. There was a remarkable absence of generalized peritonitis and a low incidence of localized abscess formation in the abdominal cavity. It is believed that early operation and postoperative treatment with penicillin or a sulfonamide or both in these cases are largely responsible for the low incidence of infection and abdominal complications in general. Only 3 cases, 1.1 per cent, had a diagnosis of intestinal obstruction made and 2 of these were from paralytic ileus. Four cases, 1.4 per cent, had abdominal biliary fistula and one had a combined biliary and urinary fistula of the right flank. The patient with biliary fistula and with hepaticophrenicopleural fistula were in general the sickest patients and required more and closer attention and care than did any others of the group. Eight patients, 3 per cent, developed hepatitis with jaundice. It was not determined if this were secondary to the liver injury or if the patient developed the infectious hepatitis which was prevalent in the theater at this time. Acute thrombophlebitis developed in 3 patients, 1.1 per cent. One patient had a phlebotomy and ligation of his femoral vein. There was no record of therapy on the other two.

RESULTS AND DISPOSITION OF PATIENTS

Table VII shows that 8.9 per cent of the patients were able to return to full combat duty an average of 60 days after injury.

An example of this class was the case of a 25 year old white male who was admitted to this hospital 8 days after receiving a penetrating wound of the right thorax with laceration of the diaphragm and liver. He had a thoracotomy after partial resection of the seventh and eighth ribs, and the diaphragm was sutured. He had an exploratory laparotomy, but no visceral damage was found except a laceration of the liver, which was packed. The only therapy at this hospital was repeated thoracenteses for the hemothorax on the right. The patient was dismissed to full duty 41 days after admission, or 49 days after injury.

There were 82 patients, 30.4 per cent, who were returned to limited duty in this theater.

An example of this class was the 29 year old white male who was admitted to this hospital 11 days after receiving a penetrating shell fragment wound of the left chest. His injury consisted of a sucking chest wound, a compound fracture of the left ninth rib, a laceration of the left diaphragm, left kidney, and spleen. Treatment at a forward hospital consisted of a thoracotomy with transdiaphragmatic abdominal exploration, splenectomy, and drainage of the left perirenal space through a flank wound. The diaphragm was sutured, and the thoracotomy wound closed. Postoperatively he had a hemothorax of the left pleural space. The only treatment required at this hospital was thoracenteses to remove the hemothorax. His convalescence was uncomplicated and he was dismissed to limited duty 55 days after admission, 66 days after injury.

Over one-half the patients, 55.5 per cent, in this series were evacuated to the Zone of Interior for further convalescence. Many of these patients, however, were evacuated because of concomitant lesions and not directly due to the thoracoabdominal injury or its complication (see Table I).

An example of a patient with a thoracoabdominal complication was the 25 year old white male who sustained a gunshot wound of the right thorax with a laceration of the lung, diaphragm, and liver. Primary treatment consisted in débridement and closure of the sucking chest wound. Thoracenteses were performed postoperatively and 12 days after injury, at a forward general hospital, he had inter-

costal catheter drainage of the right chest because of bile stained pus in the right pleural cavity. Twenty-four days after injury he had a decortication of the right lung and a closure of a bronchial fistula, and the wound in the diaphragm was closed. Thirty-six days after injury he had a thoracotomy for drainage of a recurrent empyema, and this procedure was repeated 44 days after injury. The patient was transferred to this hospital 66 days after injury, and several days later incision and drainage of a subphrenic abscess were done. On the 79th day from the onset of his illness, another exploratory thoracotomy was done with the purpose of doing another decortication because of a persistent, large empyema cavity. It was found to be impossible to decorticate the lung, so the patient was evacuated to the Zone of the Interior 125 days after injury with a large residual empyema cavity. This was the only patient in the entire series who will probably have a considerable degree of permanent disability as a result of his thoracoabdominal wound.

Seven patients in this series who died have been discussed above.

Seven of the patients were evacuated to North Africa and their final disposition is not known.

In the majority of the patients evacuated to the Zone of the Interior their wounds and colostomy, if present, were closed and healed. It is believed that only an extremely small percentage of these patients would require future surgery as a result of their thoracoabdominal wound and that the permanent disability therefrom should be practically nil.

SUMMARY

The incidence of thoracoabdominal injury was 1 per cent of all admissions to this hospital and 1.9 per cent of all battle casualties and injuries admitted.

A wide variety of lesions resulted from thoracoabdominal wounds, but the principal organs involved were the liver, 57.4 per cent; the lung, 34 per cent; the spleen, 23 per cent; kidneys, 13.3 per cent; the stomach, 13 per cent.

The patients were operated upon by a number of different surgeons, who used a variety of approaches, and no one operative procedure has found unusual favor over another.

The average time after injury until the patients were received at this hospital was 18.9 days. After arrival only 43 per cent required further operation which consisted principally of secondary closure of wounds with or without skin grafting in 36.3 per cent of cases, thoracotomy for empyema in 11.1 per cent, exploration of the subphrenic region in 5.2 per cent, colostomy closure in 4.4 per cent, and 5 decortications or 1.8 per cent, 3 for empyema and 2 for organizing hemothorax.

The mortality rate was 2.6 per cent for the series of cases. Complications were relatively few with empyema occurring in 15.9 per cent of cases and subphrenic abscesses developing in 6.3 per cent. In 9 cases transdiaphragmatic, abdominopleurobiliary fistulas developed. There were no thoracoabdominal complications in 63.7 per cent of the cases.

There were 24 patients who were able to return to full duty and 82 who returned to limited duty, a total of 39.3 per cent of the patients who were of further service to the Army in this Theatre of Operations.

DECORTICATION IN ACUTE EMPYEMA THORACIS

PAUL W. SANGER, M.D., Lieutenant Colonel, M.C., A.U.S., Charlotte, North Carolina

THE radical management of empyema thoracis in the acute and subacute phases is an attempt to eliminate chronic empyema. That there is a place for pulmonary decortication in certain cases of acute empyema is now well established. It is the purpose of this paper to discuss briefly the problem and then to present case reports which may be of value in establishing the proper indications for radical or conservative therapy.

Decortication was first practiced in this theater in cases of massive clotted hemothorax.[1] Four weeks after wounding now is considered to be the optimum time for its performance in uninfected cases. Later the same operative procedure was adopted in the management of infections in clotted hemothoraces. In these cases the operation is performed as soon as the presence of infection is established. A few have extended the use of this procedure to the management of the more severe infections in both post-traumatic and postpneumonic empyema. Some have attempted to differentiate infected hemothorax and empyema in discussing post-traumatic infections within the pleura. However, the dividing line is not clear. Without proper therapy the infected clotted hemothorax may result in a most disabling chronic empyema. With radical surgical attack the illness in acute, severe, post-traumatic or post-pneumonic empyema may be shortened to a few weeks. Infected hemothorax properly may be called empyema.

The writer has formed the following opinions: (a) Closed or open drainage (thoracostomy) is the procedure of choice in small and moderate sized, unilocular, post-traumatic or postpneumonic empyema. (b) Thoracotomy with evacuation of the pleura and decortication of the lung is the procedure of choice in multilocular empyema and in total empyema with collapse of the upper lobe. In this group fall both post-traumatic and postpneumonic infections, including those which develop in large clotted hemothoraces.

The technique of pulmonary decortication has been described by Burford and Samson. Essentially the same technique has been used in the cases which form the basis of this report. Certain points should be emphasized: (a) Intratracheal gas-oxygen-ether is the anesthesia of choice. (b) Prior to operation a cannula should be placed in an ankle vein through which blood may be administered as indicated throughout the operation. (c) Posterolateral thoracotomy, with or without rib resection, is the preferred approach (Fig. 1). (d) All free fluid and clot are removed from the pleural cavity. (e) The fibrinous membrane-like envelop which encases the lung must be completely extirpated. An attempt is made to develop a cleavage plane between the pleura and this organizing exudate (Figs. 2 and 3). In some cases this is easily accomplished; in others it may be most difficult or impossible. In empyema the fibrinous membrane may be much more densely adherent to the pleura than in uncomplicated clotted hemothorax. It is undesirable to traumatize or remove the visceral pleura but occasionally this is inadvertently done. The resulting air leaks may be plugged with fibrin foam, but if this is not completely successful, the multiple catheters which are routinely used, maintain expansion of the lung until the small fistulas are occluded. The fibrinous membrane should be removed from all parts of the visceral pleura including that in the fissures so that complete re-expansion is possible (Fig. 4). (f) It is not necessary to remove the exudate which is densely adherent to the parietal or diaphragmatic pleura. (g) It is well to test for air leaks with physiological salt solution after re-expansion of the lung prior to closure. (h) Large mushroom catheters, size 28 to 34, are placed in the 2d interspace, midclavicular line; in the 8th interspace at the posterior axillary line; and in the costophrenic sulcus, in the anterior axillary line.

[1] Samson, Paul C., Burford, Thomas H., Brewer, Lyman A., III, and Burbank, Benjamin. The management of war wounds of the chest in a base center. J. Thorac. Surg. (in press)

These are all connected to separate water-sealed bottles which are placed at least 18 inches below the level of the catheter. (i) Intercostal nerve block with 1 per cent novocain is routinely done at the conclusion of the operation. (j) Penicillin, 100,000 units in 50 cubic centimeters of physiological salt solution, is instilled into the pleura just prior to closure. The posterior catheter is left clamped for a period of 4 hours. (k) Penicillin is given intramuscularly, 25,000 units every 3 hours for a minimum period of 24 hours prior to operation and is continued postoperatively as long as indicated.

Penicillin has been given credit for the success of this radical surgery in empyema. It has, at least, given the surgeon courage to proceed in the presence of severe infection. Its importance, however, may have been overrated. It is interesting to note that in one case to be described no penicillin therapy was used. In several other cases gram negative bacilli were the offending organisms. The mechanical factors probably are of much more importance than is chemotherapy. Removal of clot, fluid, and fibrinous exudate eliminates most of the culture media for the organisms present. Multiple empyema cavities are converted into one. This cavity is largely obliterated immediately by the re-expansion of the incarcerated lung.

In the author's limited experience with decortication in the management of acute empyema, there have been no fatalities. The cases presented below are representative of the more severe types of infection.

CASE 1. An infantryman was admitted to an evacuation hospital 3 hours after sustaining multiple wounds from a rifle bullet with perforating wound of the right chest, bilateral hemopneumothorax, rigid abdomen, and paralysis of both lower extremities.

The patient was resuscitated and stabilized before a thoracotomy was performed. At thoracotomy there were revealed intercostal bleeding and perforation of the left diaphragm, as well as two holes in the stomach. The openings in the stomach were closed, the diaphragm was approximated with interrupted silk sutures; then the left chest was closed without drainage. The sucking wound of the right chest was simply débrided and closed. A suprapubic cystostomy was done at this time.

He remained in a critical condition for several days. Six days afterward, in a posterior shell with a suprapubic catheter, he was evacuated to a general hospital. Admission note recorded: "His condition was fair with complete motor loss of both lower extremities, as well as loss of sense of touch, pain, and position." The patient was moderately dyspneic with signs (initial x-ray films are not available) of fluid at his right base, but aspiration withdrew only 150 cubic centimeters of thin, turbid exudate, which by culturing grew gram negative bacilli. X-ray examination disclosed a bullet lying in the spinal canal at the level of the 1st lumbar vertebra. Emergency laminectomy 12 hours after admission, was performed and the cord was found irreparably damaged. The bullet was removed. The admission temperature was 103.8 degrees F. Postlaminectomy temperature for 10 days ranged from 102 to 105 degrees F. Repeated chest taps on the right obtained only small amounts of foul smelling fluid. X-ray pictures then showed fluid and thickness over the pleura virtually obliterating the right lung shadow.

In view of the fact that the urine was negative and the wounds relatively clean, it was obvious that the pyrexia was all due to the empyema. A catheter was placed in the 6th interspace, posteriorly, but drained only a small amount of thick, foul pus.

Fifteen days after admission thoracotomy with decortication was done even in the face of a temperature of 104 degrees F. The thoracic cavity was entered through a posterolateral incision in the 5th interspace. Multiloculated pockets of gelatinous, purulent exudate were found. The lung was collapsed and adherent in the posterior gutter area. A thick organized membrane varying from 1 to 4 centimeters in thickness covered the entire visceral and parietal pleura—this served to obliterate the lung in a collapsed position. The adherent capsule-like sheet was extirpated from the visceral pleura with careful blunt and sharp dissection. Bleeding was quite profuse. It was surprising to note that there was a definitely established vascularity between this fibrinous layer and the visceral pleura. At several sites the visceral pleura was torn—attempts were made to close the pleural rents but a small amount of air continued to leak after the lung was inflated, for which reason two anterior, as well as one posterior, catheters were used. At completion of the operation the lung was re-expanded to 90 per cent of its normal extent. The patient was in very poor condition; blood pressure had fallen perceptibly and only by forcing blood, coramine, and artificial respiration was he resuscitated.

During the operation this patient received 1500 cubic centimeters of blood, 500 cubic centimeters of plasma, and 500 cubic centimeters of saline. He was in fair condition on return to the ward. Oxygen was continued and the tubes were connected to water-seal bottles.

The postoperative course was suprisingly uneventful in view of his critical preoperative condition (complete transection of his spinal cord). The anterior catheters were removed in 7 days as the lung appeared to be sufficiently out and adherent—the posterior catheter was removed 12 days postoperatively. Chest aspiration was necessary on 3 later occasions. Preoperatively and postoperatively this patient was

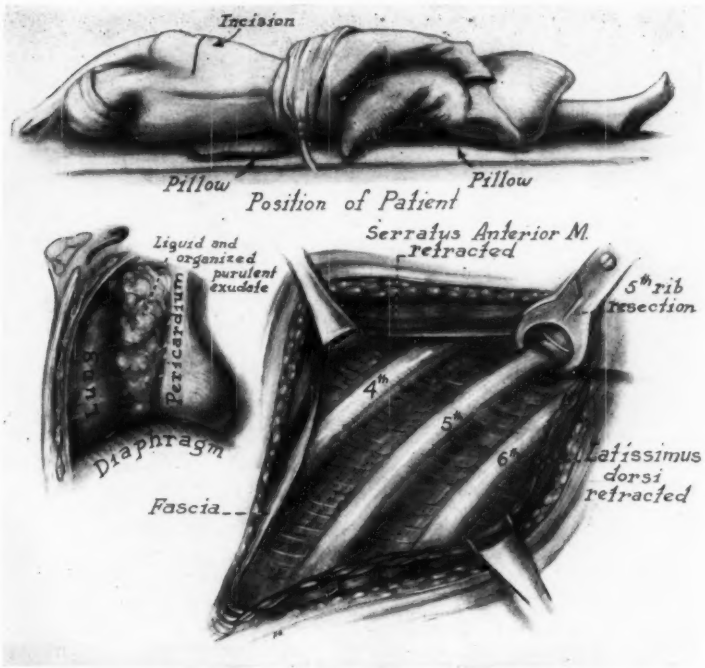


Fig. 1. Technique employed in performing thoracotomy with rib resection. An intercostal approach is optional. Cross section is of chest with total multiloculated empyema and collapse of the lung.

given large quantities of penicillin as well as sulfathiazole.

Unfortunately, a postoperative x-ray film is not obtainable.[1] At the time of his evacuation to the rear 4 weeks after decortication, the x-ray report reads: "Absence of former density and complete expansion of the upper lobe; however, the diaphragm remains elevated." Nine weeks after decortication the following letter was obtained from the rear hospital to which the patient had been evacuated. "At this time his condition relative to pulmonary status is excellent. There is minimal thickening of the chest in the right anterior base. The right lung appears fully expanded. The soldier is afebrile with no complaints of his chest or breathing. As you might judge, there has been no change in his paralysis."

Any patient that is so physically handicapped with a complete transection of the cord, so extremely toxic, with a temperature of 105 degrees F., and without the will to live is the worst imaginable operative risk. Ordinarily one would defer from proceeding with a hazardous operation, but in this incident such an undertaking offered his only chance of survival. The results amply justified this risk.

[1]Some of these patients were operated upon at a base hospital while I was there on temporary duty. Consequently, many x-ray pictures were evacuated with the patients prior to the accumulation of the material for this paper.

CASE 2. This American soldier was wounded by a shell fragment which produced a perforating wound of the left chest. He lay in an Italian hospital unattended 4 days prior to admission to an evacuation hospital, acutely ill, with grossly infected superficial wounds and empyema. Treatment was supportive with repeated chest aspirations. Hemolytic streptococci were cultured from the fluid aspirated.

Three days later the patient was transferred to a general hospital. He was in fair condition; dyspneic, temperature 102 degrees F., with signs and symptoms (Fig. 5a) of pocketed fluid and thickened pleura in the entire left chest area. He coughed continuously, producing copious quantities of white, frothy sputum without odor. Four hundred cubic centimeters of brownish, foul fluid was aspirated from the 7th interspace in the posterior axillary line, at which site a No. 24 French catheter was placed through a trocar —specimens taken produced a growth of hemolytic streptococci and gram negative bacilli on culture. The

Fig. 2. Technique employed in developing cleavage plane between the organizing exudate and the visceral pleura.

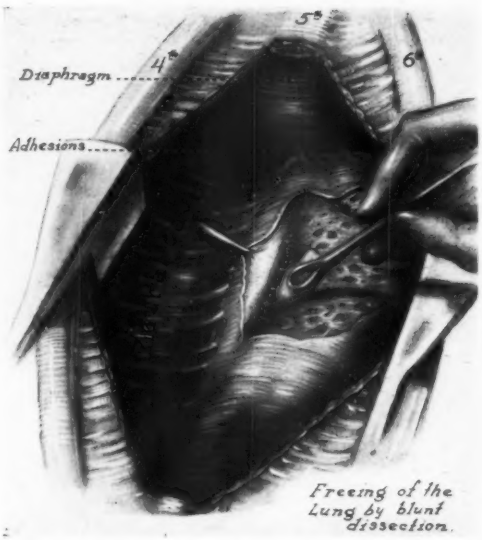


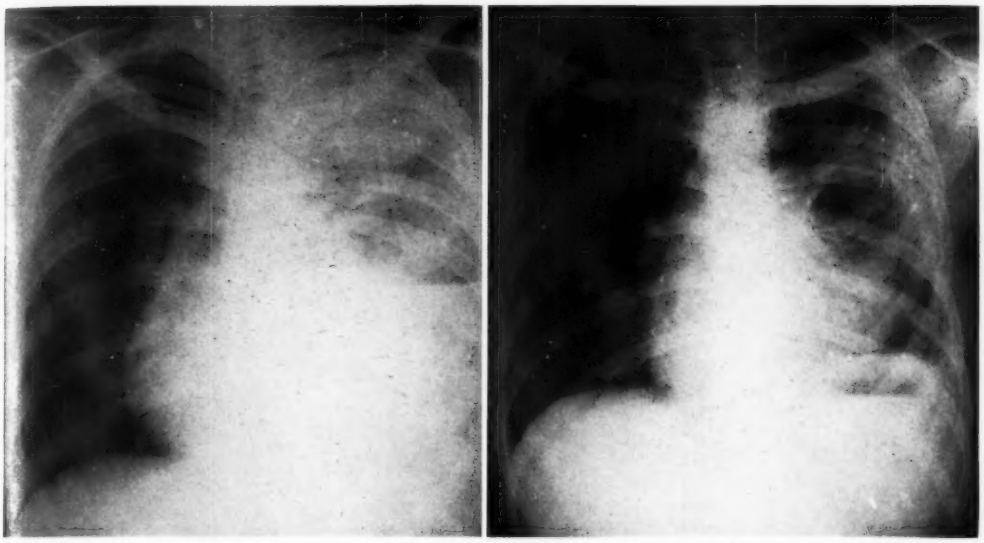
Fig. 3. Method used in removing the densely adherent membrane from the compressed lung.

temperature remained elevated to 103 degrees F. even though the catheter drained satisfactorily. Further aspiration revealed localized cavities in the anterior and midaxillary areas, for which reason (multiloculated empyema), it was deemed wise to proceed with thoracotomy and decortication. In the interim the patient was supported by several transfusions during a period of 7 days. The first 4 days after admission the soldier was given 25,000 units of penicillin every 3 hours; then by some misinterpretation of orders, the drug was discontinued, and it was never reinstituted.

Fig. 4. Lung completely freed and inflated. Re-expansion of the lung following extirpation of the constricting capsule.

At operation, under intratracheal gas-oxygen-ether anesthesia, through a posterolateral incision with resection of a 12 centimeter section of the 7th rib, the pleural cavity was found to be filled with organizing clots of purulent exudate with multiple empyema pockets. The entire lung was collapsed against the mediastinum and enveloped by a thick, 4 millimeter, tough and very adherent membrane. A clean line of cleavage could not be identified, but by slow and tedious sharp and gauze dissection, the greater thickness of this restricting sheet was stripped from the visceral pleura, although a thin membrane was too adherent to be separated except by removing small segments with the visceral pleura. However, 90 per cent re-expansion was obtained after inflating the lung with 18 millimeters of positive pressure. A No. 26 catheter was placed in the 2d interspace anteriorly, and a No. 32 catheter in the 7th interspace in the posterior axillary line. Before closing in layers with interrupted silk sutures, an intercostal nerve block with novocain was effected of the 3d, 4th, 5th, 6th, and 7th nerves.

Prior to the operation blood was started in the right ankle and the left arm; 1000 cubic centimeters, 500 cubic centimeters of plasma, and 500 cubic centimeters of 5 per cent glucose were given during the operation. Bronchoscopic aspiration was thought unnecessary postoperatively, as the bronchial system was



a b

Fig. 5. a, The areas of increased density proved to be multiple pockets of empyema. The entire lung field is further obscured by organizing fibrinous exudate. b, Re-expansion of lung after decortication. The shadow along periphery, usually termed "thickened pleura," actually is an organized membrane over parietal pleura that need not be extirpated.

relatively dry, having been successfully aspirated by a long tracheal catheter.

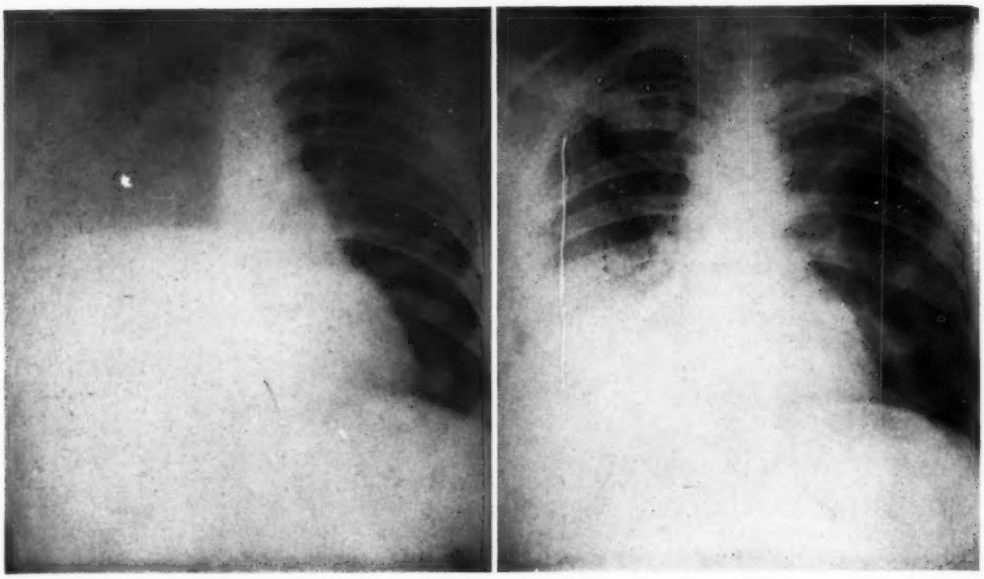
The postoperative course was without mishap. Both catheters were removed within 16 days without further pocketing or the necessity of aspiration. Twenty-eight days after operation an x-ray film (Fig. 5b) showed satisfactory re-expansion of the lung. Patient was discharged to class B duty[1] 42 days after operation.

We assumed we were protected by penicillin, but inadvertently this patient did not receive any penicillin 4 days prior to the operation or any afterward. This case represents supportive evidence that the operation is physiologically sound. Irrespective as to whether penicillin has any specificity against the infecting organism we recommend the continuance of its use.

CASE 3. This infantryman was wounded by small arms fire sustaining a penetrating wound of his right chest. Seven hours after injury a thoracotomy was done in a forward hospital. The right diaphragm was found to have been perforated and the dome of the liver was lacerated. No attempt was made to suture the liver, but subdiaphragmatic drainage was effected through a subcostal flank incision. The diaphragm was closed; then the pleural cavity was closed without drainage.

[1]Class B duty includes any type of duty except combat.

The patient was admitted to a general hospital 8 days afterward; dyspneic, slightly cyanotic, with a temperature of 102.8 degrees F. and signs and symptoms of fluid in the right chest. After aspiration a tube was placed in the 6th interspace in the posterior axillary line; there was obtained foul smelling, bile stained exudate from which gram negative bacilli were cultured. There was also drainage of a similar character from the subdiaphragmatic stab wound. X-ray examination (Fig. 6a) showed the diaphragm to be fixed and elevated. Temperature elevation continued. Penicillin and sulfathiazole were used interchangeably and together for a period of 10 days. The lung was completely collapsed and another fluid level was detected about the drainage tube. For that reason, 8 days after admission thoracotomy and decortication were done with resection of the 5th rib in the posterior axillary line. The chest cavity was filled with (Fig. 6b) yellow, bile stained, foul smelling exudate, intermixed with flaky, partly organized, fibrinous masses of pus. The lung was compressed into a small area in the posterior gutter area. The membrane which was removed from the visceral pleura with difficulty measured 2 to 5 centimeters in thickness. Oozing from the pleural surface was considerable. Transfusions of 1300 cubic centimeters of blood and 1000 cubic centimeters of plasma were necessary to sustain the patient's blood pressure to 90/60 throughout the operation. Numerous leaks in the lung were detected after its reinflation. These were closed with interrupted silk sutures, but to compen-



a c

Fig. 6. a, The diaphragm is markedly elevated and the remainder of the right lung field is greatly obscured by pus and organized hemothorax. b, Bile stained, partly organized, purulent exudate overlying the membrane-like capsule, which is compressing the lung to the posterior gutter. c, Six weeks after operation, shows satisfactory re-expansion of the lung. The patient was asymptomatic; however, the diaphragm remains elevated. This, seemingly, has no bearing on the convalescence of this type of case.

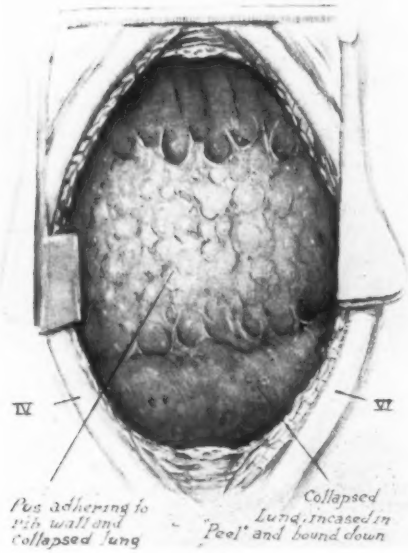


Fig. 6b.

sate for any unrecognized leakage, two catheters were placed anteriorly; one in the 2d interspace in the midclavicular line, one in the 4th interspace in the anterior line, and also one in the 7th interspace in the posterior axillary line. Bronchoscopic aspiration was performed postoperatively for excessive tenacious bronchial secretion. Oxygen was started as he returned to the ward. It should be noted that a communication through the diaphragm, 2 centimeters in diameter in the anterior medial area, could be felt, but it was thought the surrounding tissue would not lend itself to plastic repair. A large catheter was placed in the subcostal sinus beneath the diaphragm; this also was connected to a water-seal jug. It was interesting to observe respiratory motion of the water column from this catheter.

Six weeks after operation x-ray (Fig. 6c) shows that the diaphragm remains elevated and adherent laterally. Fifty-three days after decortication the patient was symptomless and was discharged to class B duty.

The infecting organism was a gram negative bacillus. Theoretically, penicillin is ineffective against such bacteria. Sulfathiazole was also given, though we fully realized drugs of the

sulfa derivation cannot effect bacteria in the presence of pus. More for luck, and for lack of courage not to give them, both were used. However, we believe they played no rôle in the recovery of this patient. True enough the diaphragm did remain elevated and a lateral shadow was apparent when the patient was discharged. All of which is accountable because of not decorticating the diaphragmatic and parietal pleura. To decorticate the parietal pleura is totally unnecessary. As for decorticating the diaphragm, the objections are: (a) it prolongs the operation on a seriously ill patient; (b) the surface oozed more freely than does the visceral pleura; (c) all patients with postoperative, high fixed diaphragms seemingly get well satisfactorily soon without this added procedure.

CASE 4. The patient was wounded in action by a shell fragment 7 hours before admission to an evacuation hospital. He had multiple wounds of his arms, right thorax, and abdomen. Resuscitation was adequately carried out prior to débriding the wounds, following which an exploratory thoracotomy was performed and then a laparotomy. Through a right thoracotomy approach the diaphragm was repaired. Laparotomy was performed through a separate incision (intra-abdominal viscera were found to be intact). The foreign body was removed from the right retroperitoneal tissue. He was evacuated to a general hospital 2 days later in fair condition. According to the admission note there was considerable subcutaneous emphysema in the right thoracic and upper abdominal regions. Aspiration of the chest revealed 350 cubic centimeters purulent, odorous fluid which was tinged with blood and 200 cubic centimeters of air. X-ray examination (Fig. 7) showed the lung 75 per cent collapsed, surrounded by a shadow which was thought to be organizing hemothorax, and also an elevation of the right diaphragm. Repeated aspirations were carried out although only a small amount of thick exudate was obtained. A subdiaphragmatic abscess was found and drained through the bed of the resected 12th rib. However, this did not alleviate the temperature elevation and symptoms of toxicity.

Two weeks afterward, a decortication was done and 1000 cubic centimeters of thick, odorous exudate was removed. There was found multiloculated empyema, rather compartmented in balls of pus. The entire upper lobe was held fast and further compressed by a thick capsule. The fibrinous layer on the visceral pleural was stripped away. Bleeding was free. Unfortunately, the pleura was torn in the removal of this capsule. Three catheters were used after operation to drain the air and the resultant exudate. Intercostal nerves were blocked interiorly. The wound was then closed with interrupted sutures of

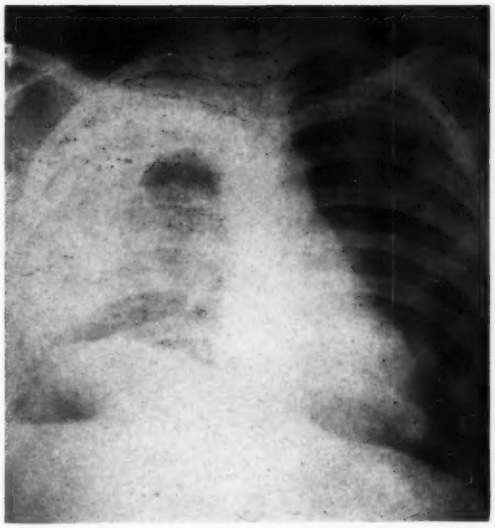
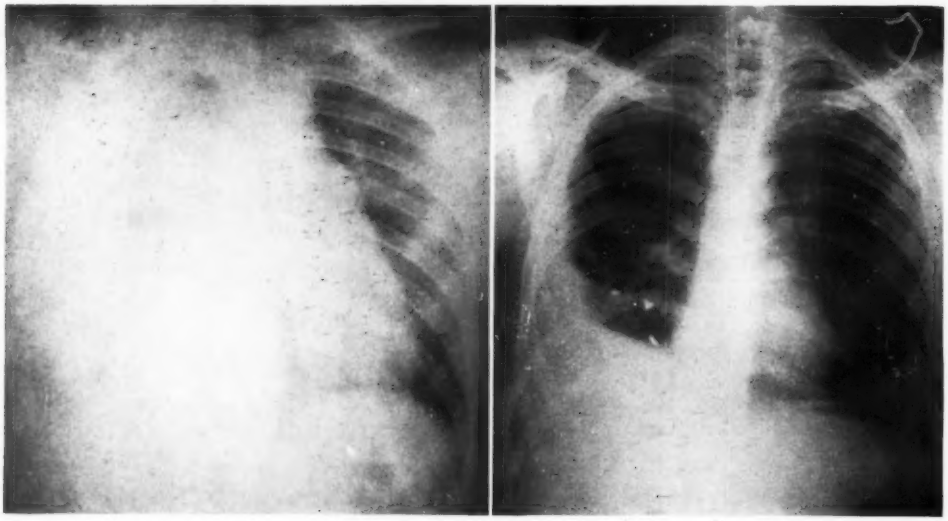


Fig. 7. Partial collapse of the right lung from what proved to be a multiloculated empyema overlying a thick, fibrinous membrane. There is elevation of the diaphragm from a fluid and gas containing pocket, which proved to be a subphrenic abscess.

silk. One-thousand cubic centimeters of blood and a liter of 5 per cent glucose were necessary to support the patient during the operation. A moderate amount of bloody exudate was aspirated through a bronchoscope at the end of the operation. After he was returned to the ward a Wangensteen suction was applied to the anterior catheter in the 2d interspace—a commercial type of apparatus being used.

The postoperative course was stormy. Suddenly he was found to be unusually dyspneic and it was then discovered that the suction apparatus was improperly connected, thus creating an artificial hydrothorax. The chest was immediately aspirated as oxygen under positive pressure was given, but the lung did not re-expand immediately. However, it did re-expand gradually, and drainage from the posterior catheter continued for a period of 33 days. The temperature ranged from 100 to 104 degrees F. 14 days postoperatively. He was discharged to the Zone of the Interior, 37 days postoperatively. There was no evidence of repocketing. His general condition was excellent and the lung had re-expanded to an estimated 85 per cent of normal. (Postoperative x-ray films are not available).

In patients that have a traumatized compressed lung for a period of 3 weeks or longer, it is noted that the lungs are nonresilient to re-expansion and any added difficulty preventing re-expansion serves as a definite hazard.



a b

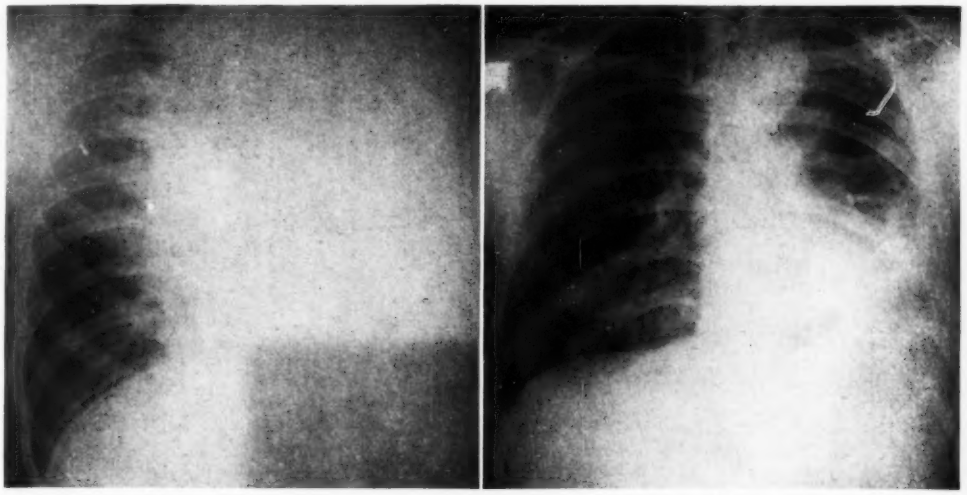
Fig. 8. a, Almost complete collapse of the right lung from multiloculated empyema and clotted hemothorax. b, Twenty-seven days after operation, the lung is re-expanded, although the diaphragm is slightly elevated. The three foreign bodies which were not removed at operation are now visible.

In this case an artificial hydrothorax was produced, which added greatly to his period of convalescence. It should be emphasized that only simple home made suction apparatus should be used in these cases. We are opposed to the use of any complicated apparatus as such frequently confuse even the expert attendant.

CASE 5. This patient was injured by a mortar shell which resulted in a sucking right hemothorax, rigid abdomen, and a compound, comminuted fracture of the right radius and ulna. He was admitted to an evacuation hospital 7 hours after wounding. His condition was fair, but he was given 500 cubic centimeters of blood and 500 cubic centimeters of plasma prior to and during débridement of wounds and exploratory laparotomy. The sucking chest wound after débridement was closed without drainage to the pleural cavity; the laparotomy revealed no visceral injury. There was no record of preoperative aspiration. After operation he was aspirated of air anteriorly and posteriorly. Intercostal nerve block, 4th through 11th nerves, was effected. The following day 1000 cubic centimeters of air and 400 cubic centimeters of fluid were withdrawn. Two days after operation a temperature of 103 degrees F. was recorded. Repeated aspirations yielded a small amount of turbid exudate at three different sites and only 100 cubic centimeters of air. Roentgenogram (Fig. 8a) revealed the lung partially collapsed and obscured by a dense thickness which was thought to be clotted hemothorax. Blood, penicillin and other supportive measures were continued. From the aspirated fluid hemolytic streptococci were cultured. Further aspirations were unsuccessful. The patient's general condition was growing worse. In view of the findings it was apparent we were dealing with a multiloculated empyema associated with organizing hemothorax. Any temporizing, such as tube drainage, would only prolong his hospitalization—for that reason decortication was performed 14 days after wounding.

The 8th rib was resected in the posterior axillary line (the incision was made unusually low to avoid the original chest wound). The chest cavity was filled with multiple compartments containing nonodorous, gelatin-like fibrin and pus. The lung was 80 per cent collapsed and held down by a well organized sheet of fibrinous exudate. This constricting band was rather easily peeled, thus allowing the lung to re-expand completely. Three small foreign bodies were known to be located in the base of the lower lobe, which was the site of a large hematoma. Due to the fact that these foreign bodies could not be palpated, it was felt unwise to attempt their removal. Three catheters were placed; two anteriorly and one in the posterior axillary line. Penicillin, (100,000 units) was then introduced into the pleural cavity. Bronchoscopic aspiration at the end of the operation yielded a moderate amount of mucus. One thousand cubic centimeters of blood were given during the operation.

The postoperative course was most satisfactory. A temperature of 99 degrees F. was the highest re-



a b

Fig. 9. a, The left chest is obliterated by fluid and a "thickened pleura." At operation it was disclosed to be a sheet, 2 to 6 centimeters in thickness, of organizing exudate. b, Roentgenogram which was taken 4 weeks following operation, shows satisfactory re-expansion of the lung. The shadow which was present at the base was attributed to the remaining fibrinous layer on the diaphragm and parietal pleura.

corded after operation. Catheters were all removed by the 7th postoperative day. Later thoracenteses found no blood, fluid, or air. At the time of discharge (Fig. 8b) the lung had completely re-expanded, but the right diaphragm remained elevated and the pleura was thickened at the base. He was discharged 27 days after operation.

This case illustrates early decortication for multilocuated empyema and organizing hemothorax with compression of the apex of the lung. The relative ease with which the organized membrane stripped from the visceral pleura is remarkable and may be attributed to early operation without preliminary drainage. It is thought that this method of management should be adopted in those cases of empyema in which decortication is indicated.

CASE 6. This soldier was treated in an evacuation hospital for a period of 10 days following chills, fever, and pain in the left chest. Diagnosis there was lobar pneumonia. He did not respond to penicillin therapy. Therefore, he was transferred to the medical service of a general hospital. The patient appeared acutely ill with a respiratory rate of 26 and a temperature of 102.4 degrees F. There was dullness over the entire left chest area (Fig. 9a) with diminished tactile fremitus. After numerous attempts to aspirate the fluid, 500 cubic centimeters of greenish colored fluid were obtained only from the 5th intercostal space in the midaxillary line. There 50,000 units of penicillin were injected into the pleural cavity. Cultures showed a few hemolytic streptococci. The patient was transferred to the surgical service 3 days after admission.

Repeated chest taps, local anesthesia being used, located purulent exudate in the 5th intercostal space in the anterior axillary line, at which site a catheter was placed through a trocar and connected to a water-seal jug. In the 9th interspace in the posterior axillary line, fluid of a different character was obtained, a greenish thin transudate. A second catheter was inserted into this pocket. Further taps did not yield additional fluid.

The catheters ceased to drain after 3 days. Knowing that multiple pockets of pus were present, the problem of individually draining them seemed impractical. Therefore, we thought the patient was a candidate for decortication.

Five days after institution of catheter drainage, thoracotomy with decortication under endotracheal gas-oxygen-ether anesthesia, was done. A posterolateral incision with resection of the 7th rib was used. In the posterior gutter the lung was tenaciously adherent and collapsed against the chest wall. Multiple thick walled pockets of cheese-like material were ruptured and evacuated. This brought us down on the thick, adherent capsule that held the lung compressed. With considerable difficulty, the visceral pleura was eventually denuded of this sheath of organizing exudate measuring 2 to 6 centimeters in thickness. Under positive pressure the lung was inflated to normal expansion. Bleeding was very annoying over the entire surface of the visceral pleura

from which the adherent sheath had been extirpated. Several rents in the visceral pleura were sutured with silk and tested under water for leakage. Closure was made in anatomical layers with silk sutures. Mushroom catheters were placed in the 2d interspace, anteriorly and in the 7th interspace in the posteroaxillary line. The patient received 1000 cubic centimeters of blood and 1000 cubic centimeters of 5 per cent glucose during and immediately after operation. Following the operation bronchoscopic aspiration was performed for excessive bronchial secretion.

Four days later the anterior catheter was removed. Progress seemed satisfactory. The posterior catheter was removed on the 7th day. No further pocketing developed. X-ray examination (Fig. 9b) showed good expansion of the lung 4 weeks after operation.

Six weeks after operation, convalescence was essentially complete with patient ready for discharge to class B duty.

This postpneumonic sequel is uncomon since the advent of chemotherapy. It was interesting to note that the pathology encountered was not grossly different from that in the multiloculated post-traumatic empyema. The capsule, however, was more tenaciously attached to the visceral pleura and there was a definite increase in the bleeding from the decorticated pleural surface.

SUMMARY

1. The indications for radical and conservative management in acute empyema are briefly discussed.

2. Certin points in the technique of pulmonary decortication for acute empyema are emphasized.

3. Six cases are presented in which thoracotomy, with evacuation of the pleura and pulmonary decortication, was employed in acute empyema. In one of these cases the empyema was a postpneumonic infection. All others were post-traumatic infections.

4. Early operation without preliminary drainage seems advisable when the indications for the radical management are present.

5. Penicillin was not used in 1 case and was of questionable value in others, but its routine use is recommended.

CONCLUSION

Early radical surgical attack in selected cases of acute empyema will greatly reduce the incidence of chronic empyema and "pulmonary cripples."

OSTEOGENIC SARCOMA

II. Roentgenographic Interpretation of Growth Patterns in Bone Sarcoma

IAN MACDONALD, M.D., and JOHN W. BUDD, M.D., Los Angeles, California

THE speech and reports of roentgenologists, when concerned with bone tumors, are studded with such words as "typical," "characteristic," and even "diagnostic." Sutherland has stated that "given adequate technique, the same information that is available in the cut section of tissue prepared for microscopic study can be obtained from the roentgenogram." More recently McNattin, relying exclusively on roentgenograms as an accurate method of diagnosis, has proposed that the primary treatment of bone sarcoma should be by massive doses of x-radiation, even to the point of necrosis.

It should be emphasized that the authors of this essay are not diagnostic roentgenologists, but we believe that radiographic arbiters such as Sutherland and McNattin ascribe to bone tumors a fixity of roentgenographic pattern that simply does not exist. Our thesis is that the roentgen-ray study of bone tumors is an interpretation of the activity of the neoplasm, and equally of the character of the stromal response. Thus the appearance of a bone tumor at a given time depends upon the balance between neoplastic activity (osteolysis), and the degree of cortical and medullary reaction (sclerosis), as well as the absence or extent of ossification and calcification. The "sun-ray" appearance of many osteosarcomas may be due either to new bone formation, or calcification in parallel striae, and may be seen in chondrosarcoma and even in neoplastic metastatic lesions of bone. Even Codman's time-honored reactive triangle may be seen in chronic periostitis. In short, "typcal" roentgenographic features are a reflection of growth characteristics rather than an indication of tumor types, *a kinetic rather than a static concept.*

The observations presented here are part of a study of 118 cured cases of bone sarcoma, and a smaller number of uncured cases, from the Registry of Bone Sarcoma of the American College of Surgeons. The primary objective in the review of these cases was to determine whether there were special features in the natural history and histopathology of the cured cases sufficiently distinctive to account for their curability. Such features have been established and were the subject of another communication, but certain general features of histopathology and nomenclature are highly pertinent here.

Of first importance is the definition of terms. The expression "osteogenic sarcoma" is used widely and interchangeably to signify a malignant tumor originating in, or producing, bone. We accept the term as indicating an origin in bone, but not necessarily producing bone, a definition which is also approved by Ewing and other writers. Osteogenic sarcoma then becomes a generic name for those sarcomas arising in the connective tissues of bone, distinguishing this numerically large group from those of less frequent incidence arising in hematopoietic, endothelial, and adipose tissue elements of the medulla.

Two of the connective tissue sarcomas of bone are well known, those predominantly producing bone and cartilage, osteosarcoma and chondrosarcoma. Our study of the cured cases emphasized the importance of the third member of the group, which is fibroblastic in nature. The proposed division of the connective tissue sarcomas is shown in the classification presented here, in which bone-producing sarcomas are designated as osteosarcoma, a proper etymological expression to match the terms chondrosarcoma and fibrosarcoma. The roentgenologist may make a diagnosis of osteogenic sarcoma with reasonable expectation of verification if there is evidence of a cortical, malignant tumor. This study has led us to the

From the School of Medicine, University of Southern California.

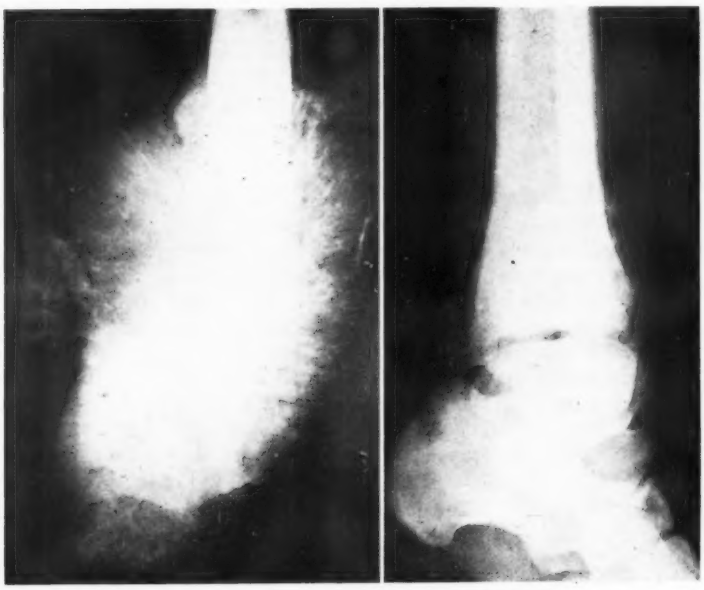


Fig. 1, left. Metastatic adenocarcinoma simulating primary osteogenic sarcoma.
Fig. 2. Chondrosarcoma, early peripheral. (1)[1] B.S.R. No. 1252.

conclusion that radiographic criteria are highly unreliable in attempting a more accurate differential diagnosis of osteogenic sarcomas.

The prognostic importance of differentiating the three connective tissue sarcomas, however, is shown in Table I. Osteosarcoma, or true bone producing sarcoma is a highly lethal disease represented by less than 12 per cent of the cured, while it accounts for 40 per cent of the fatal cases. (Table I). Fibrosarcoma is the least malignant member of the group, accounting for 37 per cent of the cured but only 15 per cent of the uncured patients. Chondrosarcoma seems to occupy a median position between these two extremes.

An interpretation of the growth pattern of bone tumors by experienced roentgenologists, according to a kinetic concept, should differentiate with almost complete accuracy between benign and malignant tumors. While the differential diagnosis of bone sarcoma into tumor types by radiographic methods seems

[1]Numbers in parentheses refer to schematic chart) Fig. 11.

MODIFIED CLASSIFICATION OF BONE TUMORS

Type of tissue	Malignant	Benign
1. Connective	Osteosarcoma, Chondrosarcoma, Fibrosarcoma } Osteogenic sarcoma	Osteoma Chondroma
2. Undetermined	Malignant giant cell tumor	Benign giant cell tumor Epiphyseal chondromatous giant cell tumor
3. Endotnelial	(a) Angioendothelioma (b) Diffuse endothelioma (Ewing's sarcoma)	(a) Plexiform angioma (b) Cavernous angioma
4. Hematopoietic Erythropoietic Myeloid Lymphoid Reticular	 (a) Erythrocytoma (b) Myelocytoma; myeloma (c) Lymphocytoma (d) Reticulocytoma	
5. Adipose	Liposarcoma	

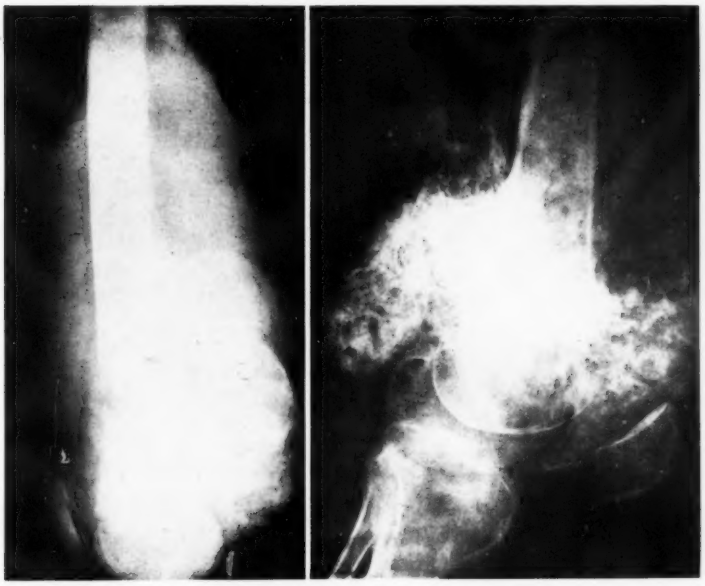


Fig. 3, left. Chondrosarcoma, peripheral. (2) B.S.R. No. 1256.
Fig. 4. Chondrosarcoma, peripheral. (3) B.S.R. No. 777.

to us more speculative, the material reviewed permits the recognition of features commonly seen in the connective tissue sarcomas.

Osteosarcoma arises in the metaphysis, and may be predominantly sclerosing or osteolytic. The sclerosing form is more common and may be peripheral or central in origin. The peripheral sclerosing is the classical type, in which the tumor early elevates the periosteum, usually with dense radiating striae and Codman's reactive triangle. With continued growth there is progressive sclerosis of the cortex and medulla, and soft tissue extension in advanced cases. The only sign of central sclerosing osteosarcoma may be a dense obliteration of the cortical striae, while secondary destruction in the medulla produces a mottled appearance.

The pure osteolytic form of osteosarcoma is the old "telangiectatic bone aneurysm" and represents a rare and extremely anaplastic form. There is irregular, expansile destruction of the cortex, little or no periosteal reaction. There may be early perforation and bulky soft tissue masses, invasion of the epiphysis and adjacent joint.

Chondrosarcoma arises in the ends of the diaphyses of long bones, in flat bones and vertebrae. There are two well defined forms, peripheral and central. In the peripheral, an irregular, productive periosteal growth is the earliest stage. Calcification is extremely common in chondrosarcoma and is responsible for its radiopacity. It may early perforate the periosteum and produce bulky, lobulated, soft tissue tumors, or blotchy, irregular masses

TABLE I.—PERCENTAGE INCIDENCE OF FORMS OF OSTEOGENIC SARCOMA IN 5 YEAR SURVIVALS AND IN NONSURVIVALS

	5 year cures		Uncured	
	No.	Per cent	No.	Per cent
Osteosarcoma	14	11.8	19	40
Chondrosarcoma	56	47.5	19	40
Fibrosarcoma	37	31.4	7	15
Complex sarcomas	4		1	
Not diagnosed	1		1	
Nonosteogenic	6			
Total	118		47	

Fig. 5.

Fig. 6.

Fig. 5. Chondrosarcoma, calcifying, peripheral. (4) B.S.R. No. 1130.
Fig. 6. Chondrosarcoma, central sclerosing type. (7) B.S.R. No. 1103.

Fig. 7.

Fig. 8.

Fig. 9.

Fig. 10.

Fig. 7. Fibrosarcoma, early osteolytic. (1) B.S.R. No. 1160.
Fig.8. Fibrosarcoma, osteolytic. (3) B.S.R. No. 1941.
Fig. 9. Fibrosarcoma, advanced diffuse osteolytic. (4) B.S.R. No. 1264.
Fig. 10. Fibrosarcoma, ossification. (5) B.S.R. No. 40.

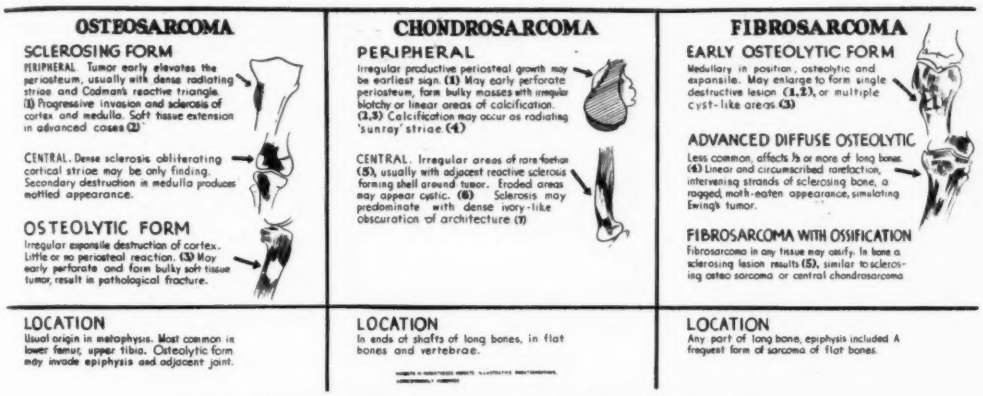

OSTEOSARCOMA
SCLEROSING FORM
PERIPHERAL. Tumor early elevates the periosteum, usually with dense radiating striae and Codman's reactive triangle. (1) Progressive invasion and sclerosis of cortex and medulla. Soft tissue extension in advanced cases (2)
CENTRAL. Dense sclerosis obliterating cortical striae may be only finding. Secondary destruction in medulla produces mottled appearance.
OSTEOLYTIC FORM
Irregular expansile destruction of cortex. Little or no periosteal reaction. (3) May early perforate and form bulky soft tissue tumor, result in pathological fracture.
CHONDROSARCOMA
PERIPHERAL
Irregular productive periosteal growth may be earliest sign. (1) May early perforate periosteum, form bulky masses with irregular blotchy or linear areas of calcification. (2,3) Calcification may occur as radiating 'sunray' striae. (4)
CENTRAL. Irregular areas of rarefaction (5), usually with adjacent reactive sclerosis forming shell around tumor. Eroded areas may appear cystic. (6) Sclerosis may predominate with dense ivory-like obscuration of architecture (7)
FIBROSARCOMA
EARLY OSTEOLYTIC FORM
Medullary in position; osteolytic and expansile. May enlarge to form single destructive lesion (1,2), or multiple cyst-like areas (3)
ADVANCED DIFFUSE OSTEOLYTIC
Less common, affects ⅓ or more of long bones. (4) Linear and circumscribed rarefaction, intervening strands of sclerosing bone, a ragged, moth-eaten appearance, simulating Ewing's tumor.
FIBROSARCOMA WITH OSSIFICATION
Fibrosarcoma in any tissue may ossify. In bone a sclerosing lesion results (5), similar to sclerosing osteo sarcoma or central chondrosarcoma
LOCATION
Usual origin in metaphysis. Most common in lower femur, upper tibia. Osteolytic form may invade epiphysis and adjacent joint.
LOCATION
In ends of shafts of long bones, in flat bones and vertebrae.
LOCATION
Any part of long bone, epiphysis included A frequent form of sarcoma of flat bones.

Fig. 11. Roentgenographic interpretation of evolution of osteogenic sarcoma.

of calcifying neoplasm. Calcification may also occur in linear, striated style, simulating peripheral sclerosing osteosarcoma. The central type of chondrosarcoma often produces irregular areas of rarefaction, usually with adjacent reactive sclerosis, forming a shell around the tumor. Eroded areas may appear cystic and resemble fibrosarcoma. Sclerosis and calcification may predominate in the central type, with dense ivory-like obscuration of architecture.

Fibrosarcoma may arise in any part of a long bone, epiphyses included. It is a frequent form of sarcoma of flat bones. The most common form is the osteolytic. In its early stage its origin may be evident as medullary, cortical, or periosteal. It may enlarge to form a single predominantly destructive lesion, with little or no reactive sclerosis or periosteal thickening. They are most commonly non-expansile tumors. Radiographic evidence of extension is frequently that of an irregular, spotty osteolytic process with or without sclerosis of adjacent bone. Multiple cyst-like areas are not uncommon and should not be confused with giant cell tumors, for the outline of the pseudocystic areas is irregular and there is usually adjacent progressive osteolysis. The microscopic picture is usually entirely comparable to that seen in soft tissue sarcomas. These forms are frequently slow or even indolent in their growth, and 5 year cures have been obtained, by amputation, after repeated local operations.

There is an advanced diffuse osteolytic form of fibrosarcoma, less common, which affects one-third or more of a large bone, in which there are linear and circumscribed areas of rarefaction with intervening strands of sclerosing bone. The result is a ragged, moth-eaten appearance which may simulate Ewing's sarcoma.

In any soft tissue fibrosarcoma, ossification may occur. Most ossifying fibrosarcomas in bone in the past have been diagnosed as osteosarcoma. Ossification in fibrosarcoma of bone results in a sclerosing lesion which may be difficult to differentiate from osteosarcoma or sclerosing chondrosarcoma. Ossification may occur only in parts of a fibrosarcoma, with other areas of osteolytic character making the diagnosis more plausible.

The simulation of primary bone tumors by metastatic lesions has been repeatedly observed by us in the past 4 years. One of the most striking of these is that shown in Figure 1. This patient's past symptom was that of pain in the thigh just above the knee. The x-ray films were diagnosed without equivocation by three roentgenologists as "typical osteosarcoma."

When a biopsy was obtained, the microscopic features were those of an adenocarcinoma metastatic from the prostate gland. Since this rather astonishing discovery, metastatic lesions from the stomach, ovary, lung, and breast have been observed as producing essentially the same picture.

SUMMARY

The roentgenographic interpretation of bone tumors is properly a study of patterns of neoplastic activity and the character of the stromal response; a kinetic rather than a static concept. The roentgenologist can determine with a high degree of accuracy the benignancy or malignancy of a given lesion. Further differential diagnosis of tumor types by radiographic methods must be regarded as speculative. Metastatic lesions may simulate perfectly the appearance of primary sarcoma of bone. Microscopic study of tissue obtained by open biopsy remains as the most essential single diagnostic method in tumors of bone. Ewing's sarcoma (endothelial myeloma) is a notable exception, for in tumors presenting suggestive evidence of this lesion, a therapeutic test with small doses of x-radiation is a valuable diagnostic aid. In general, formal biopsy of bone tumors should precede the institution of any therapeutic program, either surgical or radiological. All reliable evidence fails to establish any hazard in open or needle biopsy of bone sarcomas. To employ intensive irradiation of bone lesions on roentgenographic evidence alone is an unwarranted intellectual obeisance to a fallible diagnostic measure.

REFERENCES

1. Crowell, B.C. Supplement to 26th Year Book, p. 18. Chicago: American College of Surgeons, 1941.
2. Macdonald, I., and Budd, J.W. Surg. Gyn. Obst., 1943, 77: 413–421.
3. McNattin, R.F. Radiology, 1944, 42: 246.
4. Sutherland, C.G. Am. J. Roent., 1942, 47: 534–540.

ACQUIRED ESOPHAGOTRACHEOBRONCHIAL FISTULA

O. THERON CLAGETT, M.D., F.A.C.S., JOHN H. PAYNE, M.D., and
HERMAN J. MOERSCH, M.D., Rochester, Minnesota

ACQUIRED esophagotracheobronchial fistulas are of infrequent occurrence and have a poor prognosis and a high mortality rate. These fistulas are most often associated with malignant disease of the esophagus or trachea and occur as a late or terminal complication of the underlying pathologic process.

One must have a clear concept of the anatomic relation of the esophagus to the trachea in order to appreciate the ease with which these fistulas may occur. The esophagus begins at the level of the cricoid cartilage and descends in front of the vertebral column through the superior and posterior mediastinum. It passes through the diaphragm and ends at the cardia of the stomach. The trachea lies just anterior to the upper portion of the esophagus, being separated from it by a few lymph nodes which are most numerous in the region of the bifurcation. As the esophagus descends in the thorax, it curves to the left and is crossed by the left main bronchus. It then passes to the right and behind the arch of the aorta and, descending in the posterior mediastinum, lies to the right of the thoracic aorta. Lower in the thorax it passes to the left and anterior to the aorta. Since the trachea and the upper part of the esophagus lie in such close apposition, it is easy to understand how a pathologic process of one organ may spread and involve the other organ secondarily.

CAUSES

There are five main causes of esophagotracheobronchial fistulas. In order of their frequency they are as follows:

1. Malignant disease of the esophagus
2. Infectious disease of the esophagus, trachea or pleura
   - A. Tuberculosis
   - B. Syphilis
   - C. Fungus infections
   - D. Suppurative esophagitis
   - E. Nontuberculous empyema
3. Traumatic injuries of the esophagus
4. Esophageal diverticula
5. Esophagomalacia

Carcinoma of the esophagus is the most frequent cause of fistula formation. Ewald stated that 50 per cent of carcinomas of the middle third of the esophagus are associated with fistula. Tinney and one of us (H.J.M., 15) reported a series of 39 cases of fistula; in 14 cases (36 per cent) the fistula was associated with carcinoma of the esophagus. In 4 cases (10 per cent) the fistula was the result of a malignant lesion which arose in the thyroid, in the trachea or in the bronchus.

Lymphoepithelioma of the lower part of the pharynx may also cause fistula formation. Boyd and Goldbloom have reported a case of this nature.

Infectious diseases of the esophagus, trachea, pleura, or adjacent lymph nodes are the second most common cause of fistula. Tuberculosis is a frequent etiologic factor; it may cause fistula formation in several different ways. Heddaeus and Riviere expressed the belief that fistulas may arise from a breaking down of caseous lymph nodes which ulcerate into the trachea and esophagus. In Pachnio's opinion, tuberculosis causes an esophageal ulceration with subsequent perforation. Kelly and Henderson expressed the belief that tuberculous lymph nodes may perforate into the trachea and esophagus as the result of a slow process of ulceration on the outer walls of these structures. In their opinion also, tuberculous lymph nodes in healing may cause the formation of traction diverticula, which enlarge, ulcerate, and finally rupture to form a fistula. Tuberculous ulcers of the trachea or bronchi may perforate into the esophagus and form a fistula. Tuberculous empyema of long standing occasionally will cause an esophagobronchial fistula to form.

Syphilis may cause the formation of esophagobronchial fistula in two ways. It may give rise to gummas in the esophagus or air passages, which eventually ulcerate, perforate, and form fistulas. Bucher and Ono reported 13 cases of this sort. Syphilis also may cause fistula formation through the development of an aneurysm which, from prolonged pressure, may produce an esophagotracheal fistula. Dorner has reported a case of this nature.

Actinomycosis is a rare cause of fistula formation but Vinson and Sutherland reported such a case. The patient lived for 20 years after the development of the fistula.

From the Divisions of Surgery and Medicine, Mayo Clinic.

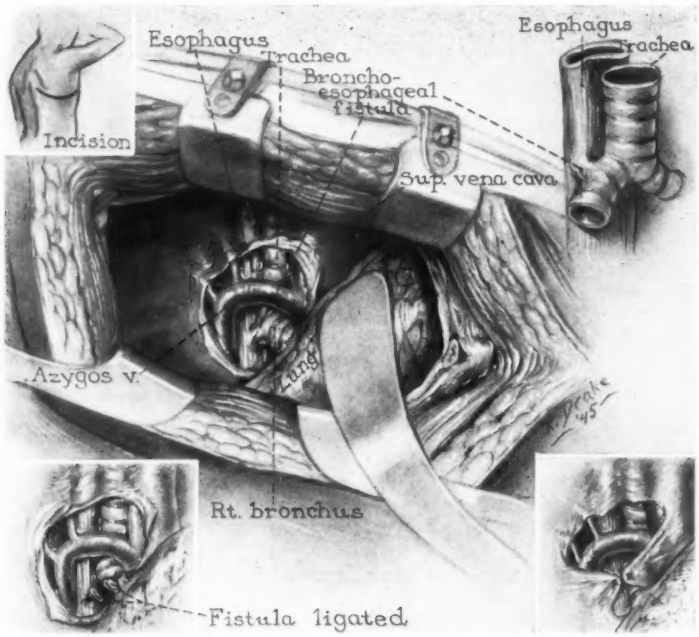


Fig. 1. Fistulous tract between the right main bronchus and the esophagus. Its relation to the azygos vein and to the superior vena cava and the trachea is well seen. Insets show the incision, a larger view of the fistula, the fistulous tract ligated and the reinforcement of the ligated ends of the fistulous tract with pleura.

Phlegmonous or suppurative esophagitis may give rise to a fistula. Such an inflammatory process may result from the action of some corrosive chemical that has been swallowed or it may be secondary to a pulmonary or pleural infection of long standing. Berman and Walters reported a case in which a fistula was due to nontuberculous empyema. In cases of nontuberculous empyema, fistulas are more likely to occur when a hard rubber tube has been used to drain the pleural space for a prolonged period than under other conditions.

Traumatic perforation of the esophagus, either by some foreign body or by instrumentation, may give rise to a fistula. Rarely diseased bone in an adjacent vertebra may cause fistula formation. Judd, Havens, and two of us (O.T.C. and H.J.M.) reported a case in which fistula was due to a bullet wound. Surgical treatment of the fistula was successful. Murtagh and Tyson have reported a fistula due to a piece of bone lodging in the anterior esophageal wall. The fistula healed promptly and completely on removal of the bone.

Esophageal diverticula, whether they are of the congenital or of the acquired traction type, occasionally cause the formation of fistulas. These arise because of inflammation and ulceration of the diverticulum with secondary perforation into the trachea or bronchi. Occasionally, the diverticula may cause a mediastinal abscess which can rupture into a bronchus, thereby forming a fistula.

Davidson and Mills stated that esophagomalacia is a rare cause of esophagobronchial fistula. This occurs as an agonal manifestation in cases of cerebral disease, as a result of digestion of the esophageal walls by gastric contents.

SYMPTOMS

Although, as a rule, congenital tracheo-esophageal fistulas manifest their presence at once by a definite group of symptoms, acquired fistulas may be present for varying periods before they produce symptoms. There is generally a history of varying degrees of dysphagia gradually increasing in severity. Then suddenly cough develops as well as dyspnea when the patient eats

and he raises purulent sputum and occasionally blood. At first these symptoms follow the ingestion of liquid foods but, later on, they may follow the ingestion of either solid or liquid food. Lukens and Ono stated that coughing and dyspnea are most likely to occur when the patient is on his left side, in an upright position or leaning forward when he swallows. Allen has reported 2 cases (proved roentgenologically) in which a fistula was present but the patient had not had any symptoms. If one suspects the presence of an esophagotracheobronchial fistula, a bronchoscopic and an esophagoscopic examination should be performed in an endeavor to visualize the fistulous opening. A roentgenoscopic examination of the esophagus should also be performed after the patient has swallowed a small quantity of radiopaque oil. These patients should not be given barium to swallow, as it is very irritating to the parenchyma of the lung whereas radiopaque oil is not.

TREATMENT

The treatment of esophagotracheobronchial fistula varies with the cause of the condition. When fistula arises from malignant disease, there is really no treatment available, as the fistulas are terminal complications and the patients will die of the malignant lesion regardless of their treatment. Some of the other types of fistula, though, are amenable to various forms of therapy. Clerf, Cooley and O'Keefe have reported 2 cases in which esophagotracheal fistula was successfully treated by the application of crystals of sodium hydroxide. These crystals were fused on an applicator and pressed against the fistula for 3 minutes. This procedure was repeated 3 weeks later. Imperatori has reported a case in which a high fistula was treated by excising the fistulous tract and closing the esophagus and trachea separately with interrupted sutures. This procedure was done by opening the anterior wall of the trachea and working on the fistulous opening in the posterior portion of the trachea. When these fistulas arise from empyemas, Cohen and Sindell advocated adequate drainage of the pleura and prolonged esophageal rest by the use of nasal tube feedings or gastrostomy feedings. This regimen is followed until the esophageal fistula has had adequate time to heal. Judd, Havens, and two of us (O.T.C. and H.J.M.) have reported a case in which a traumatic fistula was closed by excision of the fistula and individual closure of the esophagus and trachea with reinforcement of the suture lines by transplantation of the omohyoid muscle into the area.

REPORT OF CASE

We wish to report an additional case at this time in which the fistula was cured by operative intervention. The patient was a 59 year old white woman whose past history was negative except for a previous ectopic pregnancy that had been handled surgically. She had been in good health until 3 years before her admission to the Mayo Clinic. At this time a piece of meat had entered her trachea while she was eating, and, after this, a cough and an aching in her thorax developed. Six weeks later the meat was removed with a bronchoscope. She continued to cough, however, and on one occasion coughed up some pieces of calcified material. Her general health was good until one year prior to admission when progressive dysphagia developed. She soon noted severe paroxysms of coughing on taking liquids and regurgitated the liquids. She gradually lost 40 pounds (18.1 kgm.). At the time of our esophagoscopic examination she was found to have a sinus opening on the right lateral wall in the middle third of the esophagus. On bronchoscopy she was found to have a fistulous opening in the posterior wall of the right main bronchus through which esophageal secretion was coming.

Surgical exploration and closure of the fistula were advised. Preoperatively the patient was given 4 grams of sulfadiazine for 3 days. Transthoracic exploration was performed through a right posterior lateral incision, with removal of part of the sixth rib. Exploration of the esophagus and the lower part of the trachea disclosed a fistulous tract between the esophagus and the right main bronchus with many calcified lymph nodes in the region (Fig. 1.). After the fistula had been dissected free, its esophageal end was ligated and turned in with interrupted catgut sutures. The bronchial end of the fistula was ligated separately and covered with pleura. The operative site was washed with saline solution and zephiran chloride (1:10,000) and 5 grams of sulfanilamide were dusted into the pleura. An intercostal catheter was inserted and the thorax was closed in layers. A Levine tube was passed into the stomach. The patient was given 80,000 units of penicillin intramuscularly each day for the first 11 postoperative days.

Jejunostomy feedings were begun through the Levine tube on the second postoperative day. The patient was allowed to drink clear liquids on the seventh day and the nasal tube was removed on the tenth postoperative day. A liquid diet then was begun and was gradually shifted over to a soft diet.

When the intercostal catheter was removed on the fourth postoperative day, the lung remained well expanded. Thoracentesis was performed on the eighth and twelfth days and the patient was dismissed on the twenty-first day, in good condition. She was eating a soft diet and had not experienced any dysphagia, dyspnea, or coughing since the operation. The report of the pathologist on the specimen of tissue that was removed at operation was "chronic inflammation and tuberculosis."

CONCLUSIONS

In conclusion, one may see that these esophagotracheobronchial fistulas are a serious problem. In cases of fistula caused by some malignant condition the malignant disease itself is fatal. Those fistulas not associated with malignant conditions have a more hopeful outlook, although many of these patients, regardless of the cause of the fistula, die of aspiration pneumonia, pulmonary abscess, or gangrene. This is especially true when

the fistulas are of considerable size. Direct surgical attack with closure of the fistula is feasible in some instances and some of the smaller fistulas may be treated adequately by the local application of crystals of sodium hydroxide.

REFERENCES

1. Allen, W. E., Jr. Radiology, 1934, 22: 366-368.
2. Berman, J. K., and Walters, C. E. Ann. Surg., 1943, 117: 100-105.
3. Boyd, L. J., and Goldbloom, A. A. Bull. N. York M. Coll., 1938, 1: 39-45.
4. Bucher, C. J., and Ono, Jo. Am. J. Path., 1934, 10: 391–398.
5. Clerf, L. H., Cooley, E. E., and O'Keefe, J. J. Surg. Gyn. Obst., 1943, 77: 615–617.
6. Cohen, W., and Sindell, E. A. West. J. Surg., 1942, 50: 238–249.
7. Davidson, P. B., and Mills, E. S. Med. Clin. N. America, 1923, 7: 999–1017.
8. Dorner, G. Quoted by Davidson, P. B., and Mills, E. S. (7).
9. Ewald. Quoted by Davidson, P. B., and Mills, E. S. (7).
10. Heddaeus, Jul. Quoted by Davidson, P. B., and Mills, E. S. (7).
11. Imperatori, C. J. Arch. Otolar., 1939, 30: 352–359.
12. Judd, E. S., Clagett, O. T., Havens, F. Z., and Moersch, H. J. Proc. Mayo Clin., 1944, 19: 108–112.
13. Kelly, A. B., and Henderson, F. L. J. Lar. Otol., Lond., 1939, 54: 95–98.
14. Lukens, R. M., and Ono, Jo. Laryngoscope, 1934, 44: 334–339.
15. Moersch, H. J., and Tinney, W. S. Med. Clin. N. America, 1944, pp. 1001–1007.
16. Murtagh, J. A., and Tyson, M. D. N. England J. M., 1940, 222: 494–495.
17. Pachnio, F. Quoted by Davidson and Mills (7).
18. Riviere. Quoted by Davidson and Mills (7).
19. Vinson, P. P., and Sutherland, C. G. Radiology, 1926, 6: 63–64.

GUNSHOT FRACTURES OF THE FEMORAL SHAFT

ERNEST A. BRAV, M.D., F.A.C.S., Lieutenant Colonel, M.C., A.U.S., and
WILLIAM T. FITTS, JR., M.D., Captain, M.C., A.U.S., Philadelphia, Pennsylvania

A ZONE of Operations often affords an unusual opportunity of observing large numbers of compound fractures of the femoral shaft, an injury not often encountered in civilian practice. This study is based upon a series of 82 cases received at a General Hospital during the campaign in North Burma from October, 1943 to August, 1944. It includes all complete compound fractures of the shaft, some of which were comminuted into the knee joint. Purely condylar fractures and those involving the head and neck are not included because they bring up different problems in management. This study has, it is believed, enhanced value because the majority (85%) of the cases were Chinese soldiers, and it was possible for us to observe the patients from very shortly after their injury until the time when the end-results could be ascertained with a reasonable degree of certainty. American soldiers, comprising 15 per cent of the series, were evacuated to the Zone of the Interior as soon as this could be done with safety. The mortality of the entire group was 4.9 per cent.

There was no significant variation in the side of the body concerned, but the lower third of the shaft was most commonly involved. Approximately half of the cases were at this level, and 8 of these, 10 per cent of the total, involved the knee joint. Middle third fractures are common in civilian practice, but accounted for only one sixth of this series. The remaining third were in the proximal portion of the shaft. A rifle bullet was said to be responsible for the wound in 51, 62 per cent, of the cases, and shell fragments, most frequently from a mortar, accounted for the others.

TIME OF ADMISSION

Sixty per cent of the patients were admitted within 48 hours of injury and of these two thirds were admitted within the first 36 hours. Early in the campaign there were delays in evacuation in a number of instances, so that the average time interval was 5.9 days from injury to admission. Once the air evacuation system had been perfected, patients were received within an astonishingly brief time, especially when it is realized that a litter haul for varying distances was required before a plane trip of 100 miles or more.

MANAGEMENT BEFORE ADMISSION

Débridement. It is our opinion that in a great majority of patients the treatment received in the forward areas was of the highest quality. Of the 82 cases, 70, or 85 per cent, had received wound débridement prior to admission. There were 10 patients, 12 per cent, who had not been débrided prior to admission. One of these had a primary type of wound excision performed after admission, but the others presented wounds which were not considered suitable for any procedure other than the providing of adequate drainage. In 2 cases it was uncertain from the data accompanying the patient and from the appearance of the wound whether débridement had been performed. Of the 70 cases in which débridement had been done, the time interval between injury and operation was accurately determined in 66. It is a tribute to the medical personnel in the forward areas that 51, 77 per cent, of these were débrided within 12 hours and that only 15, 23 per cent, had operations after that period. Of the entire group of 82 patients, it is known that 62 per cent were débrided within 12 hours of their injury.

The débridement, it is felt, was adequate in most cases. Improvement in the condition of the wounds was readily noted as the experience of the forward surgeons increased. In a few cases it was apparent that there had not been sufficient incision of the deep fascia and in some, injured muscle and foreign bodies were not removed, thus causing subsequent difficulties. Occasionally vaseline gauze had been inserted tightly in the wounds and acted as a cork instead of a drain. In such instances removal of the gauze was followed frequently by a gush of purulent material. Wide incision of skin to explore the depths of the wound, and counter incisions posteriorly on the medial or lateral side, were recognized as helpful measures in avoiding wound complications.

It is not known how many patients with this type of injury succumbed to shock or hemorrhage in the forward areas. However, it soon became apparent that next to the treatment of shock and hemorrhage, the adequacy of the débridement was the most important part of the primary treatment both as to the saving of lives, the avoidance of soft tissue and bone infection, and the rapidity of convalescence.

Suture. In only one instance had the wound been sutured before admission. The sutures were removed upon arrival at the hospital. Our experience with other cases in which battle wounds were sutured primarily has convinced us of the wisdom of the Surgeon General's Circular letter No. 189, dated November 17, 1943, which forbids primary suture of such wounds. The gravest complications may ensue if immediate closure is performed. In none of our cases had any form of internal fixation of the fracture been attempted.

Immobilization. The commonest type of immobilization used in the forward areas was the plaster spica. Most of these were double spicas, with plaster down to the toes on the affected side and to the knee on the opposite side. Of the entire series, 68 patients, 83 per cent, were so immobilized. Although many of the spica plasters were broken at the groin, the patients were for the most part comfortable, and this method of temporary fixation seemed entirely satisfactory. In 3 cases a Kirschner wire had been inserted through the femur and incorporated in the plaster, but this seemed unnecessary. In our opinion, the function of the forward stations, once excision and immobilization has been accomplished, is to evacuate the patient to a fixed installation for definitive treatment as soon as possible. If this can be done within a week, only ordinary precautions need be taken for the maintenance of length and for the proper alignment of fragments. The only thing that is required, after the care of the wound and the treatment of shock and hemorrhage, is comfortable transportation by a method which will prevent motion of the fragments. Adequate reduction can be obtained when the fixed installation has been reached.

It is inadvisable to cover with plaster any wound that has not been débrided, unless specific notation of this omission has been written plainly upon the plaster. It is also inadvisable to apply a nonpadded plaster when a patient's circulation cannot be continually and carefully watched. Padded plasters should always be used for transportation. If unpadded plasters have to be used because of lack of suitable material for padding, the plaster must be split longitudinally through its entire length. The application of a nonpadded plaster, especially in the region of the calf, proved to be an important factor in producing circulatory disturbances in several of our cases. Plaster fixation is a definite disadvantage in those instances in which wound infection is suspected. If infection is likely, a window should immediately be made over the wound for early inspection, or the plaster should be removed entirely. It is probable, if earlier wound inspection had been made, that one of the deaths in this series could have been prevented.

In 12 cases, 15 per cent, immobilization was obtained by means of the Army half ring leg splint. This splint gave satisfactory temporary immobilization of the fragments but several points are worthy of mention. Any form of hitch used around the foot and ankle is dangerous because it may produce circulatory obstruction or pressure necrosis. Skin traction by means of broad adhesive strips or stockinette is the method of choice. Circular adhesive strips should not be used. Smoothly applied gauze bandage should be used to anchor the adhesive. Pressure from adhesive over the malleoli and over the head of the fibula should be avoided. The adhesive or stockinette should extend to a point just below the wound. When possible, a wooden spreader should be employed. If the lateral adhesive strip is applied somewhat more posteriorly than the medial one, there will be a tendency to correct the external rotation deformity.

The "Tobruk splint" was not used in any of our cases. In 3 of them, however, the wound and the adjacent area of the Army leg splint were incorporated in a plaster cuff. It is felt that when there is a shortage of plaster in the forward areas, immobilization can be satisfactorily obtained by means of the Army leg splint, provided that such fixation is not maintained for more than a few days and that no ankle or instep hitches are used. The plaster spica, however, is preferable.

Two patients arrived without any form of immobilization. Both were in poor general condition and had severely infected wounds.

Sulfonamides and antitoxin. In 94 per cent of the patients there was either a written record of sulfanilamide having been used in the wounds or evidence of it on inspection. It is entirely possible that sulfonamides were applied locally to all wounds. In 40 per cent of the cases a history or written record of the oral use of sulfonamides was obtained. It is probable that a large number had taken the drug. Two sulfonamides, sulfadiazine and sulfathiazole, were used, and these in about an equal number of cases.

A stimulating dose of tetanus toxoid had been administered to all American soldiers prior to admission. Most of the Chinese had received 1500 units of tetanus antitoxin. Those who had not previously received it were given antitoxin at the hospital. No case of tetanus developed. Gas bacillus antitoxin was administered prophylactically in a few selected cases.

In summary, it is our opinion that the following factors are of greatest importance in the early management of these cases: (a) treatment of shock and hemorrhage, (b) thorough wound débridement, (c) local and oral sulfonamide therapy, (d) adequate immobilization, and (e) rapid evacuation to a fixed installation. Fracture reduction and maintenance are of secondary importance. These are functions of the fixed medical installations.

CONDITION ON ADMISSION

General. Although all the patients presented some degree of anemia and malnutrition and showed the effects of exposure, only 18, or 22 per cent, were thought to be in poor general condition. This latter group consisted chiefly of patients with wound infection, especially by gas-forming organisms, and patients with septic arthritis of the knee joint. The average hemoglobin determination in the entire group was 9.7 grams; the white cell count averaged 10,000. There were, of course, wide variations, the hemoglobin being as low as 4.5 grams, white count reaching 26,000.

Wounds. It was not always possible at the time of admission to determine which wounds were "infected." In our earlier cases there was a tendency to postpone inspection of the wound as long as possible in order to avoid contamination. It was later realized, however, that the usual criteria—fever, rapid pulse, leucocytosis, and general appearance—were not always reliable indications of infection, especially infection due to gas-forming organisms. As our experience increased we tended to inspect the wounds earlier and upon slight suspicion. On the other hand, it is conceded that wounds which appear superficially infected on initial inspection may heal without complication if undisturbed. We feel that the error of omission is the more serious. The average period before wound inspection was 4 days in the entire series, but the large number of immediate or 24 hour inspections was offset by one case in which the wound was not examined for 8 weeks. It was felt that once we could assure ourselves of the appearance of the wound and the adequacy of the débridement, subsequent dressings could be kept at a minimum.

There were 2 instances of massive gas gangrene and 3 of gas cellulitis. Otherwise there were no patients with spreading soft tissue infections, invasive cellulitis, or lymphangitis. A large number of wounds contained superficial necrotic material, and many showed evidence of surface infection. A few wounds had been plugged with vaseline gauze, and spreading infection was undoubtedly prevented by prompt removal with release of dammed-up blood and exudate. The first inspection of the wound revealed evidence of deep abscess formation in 4 instances. Secretions from the wounds were not routinely cultured.

In wounds which had penetrated the knee joint there was a high incidence of infection. Of 8 such cases, 4 developed joint infection, and these were the sickest patients of the group and the most difficult to treat.

We believe that early inspection of thigh and knee wounds following admission to a fixed installation is a good general principle if the initial toilet of the wound has been carried out elsewhere. Gas infection can be discovered at the earliest possible moment; a secondary débridement can be done if the primary operation was inadequate; deep soft tissue infection can be controlled by early drainage; and the form of subsequent treatment can be more readily determined. Afterward, if the wound is satisfactory, minimal frequency of dressing is advisable.

Metallic foreign bodies were noted in the wounds by roentgenologic examination in 33 patients, 40 per cent, many of them multiple.

Fractures. It has been a common observation that in gunshot fractures of the long bones there occurs very marked comminution and fragmentation, but it is generally noted that the classical bone displacements do not occur. This series of cases, however, was rather consistent in demonstrating the typical displacements of the fragments. In the upper third, the proximal fragment was commonly flexed, abducted, and externally rotated. In fractures of the middle of the shaft, there was usually a slight amount of flexion of the proximal fragment. The lower third fractures almost invariably presented posterior displacement of the lower fragment due to the pull of the gastrocnemii. Approximately 80 per cent of the fractures in this series were in poor position upon admission to the hospital. Since they were received relatively early, this fact played little part in the ultimate results.

Associated injuries. Circulatory embarrassment is one of the gravest causes for concern in the management of these patients. It is significant to note that in 9 cases, 11 per cent, there was evidence of impaired circulation of the extremity. Most of these occurred in nonpadded plasters, and when the plaster was split, constriction was noted, usually at the calf. Except for 2 cases of gas gangrene which resulted in death, the circulation returned to normal following the splitting of the plaster through its entire length. We found hypesthesia and hypalgesia to be the usual early

warning signals of circulatory impairment, followed by various combinations of anesthesia, swelling, paralysis, and changes in color and temperature of the skin.

Only 5 cases, 6 per cent, showed evidence of sciatic nerve injury. Special care was taken to support the foot in the neutral position and to avoid contracture of the tendo achillis. Nerve exploration and repair were performed by the neurosurgeons after the fractures were healed.

HOSPITAL TREATMENT

General. In all cases the general treatment of the patient was considered to be of equal importance with the local care of either the wound or the fracture. Anemia was corrected as soon as possible. Patients with low hemoglobin were given repeated transfusions of whole blood, and oral iron preparations were prescribed for nearly all the cases. In our opinion, the rapid restoration of normal hemoglobin was one of the most important factors in the prevention of infection.

Patients presenting poor nutritional states were given multiple vitamin preparations, and a liquid formula high in protein was used as a supplement to the regular diet. No additional calcium was prescribed, although there was a deficiency of this element in the diets of both the American and the Chinese patients.

All patients were given oral sulfonamides, either sulfadiazine or sulfathiazole, in doses of 4 to 6 grams daily. The drug was continued for a few days following the fall of the temperature to normal. There were no untoward effects noted from the use of these drugs. Efforts were made to maintain the urinary output above 1,000 cubic centimeters daily in order to avoid renal complications. There were no proved cases of drug sensitivity or of sulfonamide fever.

Penicillin in limited amounts was available during the latter half of the study, but it was not used prophylactically as were the sulfonamides. In certain infected cases penicillin was used intramuscularly and also locally in the wounds. No conclusions could be drawn from our small experience, but it was our definite impression that the general constitutional improvement was much more noticeable than the local effect of penicillin in the wounds. It was also apparent that adequate surgical drainage was a prerequisite to the effective use of penicillin in any instance.

Soft tissue wounds. In only 1 case was primary excision of the wound performed at this hospital. In all the other cases, débridement had been performed in the forward areas or the wounds were considered suitable only for incision, drainage, and removal of foreign bodies. Clean wounds were treated by cleansing the surrounding skin and the application of sulfanilamide crystals to the wound itself. Vaseline gauze was lightly applied to the wound in funnel fashion to provide drainage to its depths without having the effect of a plug cork. After the initial wound inspection, dressings were infrequent. In the plaster cases dressings were done every 4 to 6 weeks or even less frequently. In the balanced traction cases, the frequency depended upon the amount of discharge on the dressings.

All wounds were immobilized either in plaster or by means of traction suspension. The advantages of the closed plaster technique were offset in the majority of cases by the more efficient management of the fractures by means of skeletal traction. It is believed that the healing of the wounds did not suffer as a result of this form of treatment. Of the cases eventually developing bone infection, the plaster and traction-suspension methods were represented equally.

Wounds which presented superficial slough were immediately treated by means of 1 per cent chlorazene solution on gauze dressings which were moistened twice daily. The surrounding skin was protected by zinc oxide ointment. This was found to be an effective method of cleaning up the wounds, after which the sulfonamide and vaseline gauze technique was used.

There were 3 cases of definite anaerobic cellulitis without actual gangrene. They were treated successfully by incision of the wounds, excision of necrotic tissue, counter-incisions when indicated, and the local application of a potent zinc peroxide suspension.

Skin grafts and secondary suture of wounds were not performed until the period of fracture immobilization had been completed. In retrospect, we feel that this was a mistake. Many secondary sutures probably should have been done on first inspection of the wound in the operating room or later on in the ward while the patients were still in traction suspension.

In 8 patients, deep abscess formation developed in the various thigh compartments. These abscesses responded well to incision and drainage with the generous use of counter incisions in the posterior portions of the thigh, both medially and laterally. In this connection it is well to note that flexion of the thigh in the traction suspension apparatus is especially favorable to the development of "gravitational abscesses" proximal to the wound. Suspicion must always be maintained in regard to deep thigh abscess formation. Especially in the anterior portion it is often difficult to

obtain clinical evidence of abscesses beneath the deep fascia. Knee joint collections must be suspected in supracondylar fractures. In these cases, in addition to wide knee joint drainage, elevation of the limb should be kept at a minimum to avoid gravitational abscess formation. Incision and drainage may be done on the ward, without removal from traction, under intravenous anesthesia with sodium pentothal.

Fractures. Originally it was planned to treat groups of these fractures by 3 different methods: (a) by immobilization in a plaster spica after reduction on the fracture table, (b) by skeletal traction with suspension, (c) by some form of external skeletal fixation. The first method was soon discarded except for a few selected cases discussed below. We found it was often difficult to obtain satisfactory reduction in this way and even more difficult to maintain it. We should have known that this would be true. When casualties began to arrive in large numbers, the pressure of work and the requirement of additional time and personnel precluded trial of the third method. Open reduction was not attempted.

Of the entire group of 82 cases, 10 were treated by the plaster spica method. Except for fractures of the proximal third, single spica plasters were used, the plaster extending from the opposite costal margin to the toes on the affected side. There were 2 groups of these patients. In the first group, the patients arrived in the hospital too late to obtain improvement by traction or manipulation. It was our feeling that correction could be obtained up to about 3 weeks but it was usually impossible thereafter. The second group was comprised of patients who arrived with fractures in excellent position and in whom we felt that there was little danger of displacement as a result of this method. At the end of 8 weeks the plaster below the knee was cut away posteriorly so that active and passive knee motions could be instituted. Three of these patients had infected wounds which were dressed frequently through windows in the plaster. The other 7 were treated by the closed plaster technique. Immobilization was maintained in all cases for 12 weeks and as long thereafter as was required to obtain roentgenologic evidence of bone union.

The remaining 72 patients were treated by the balanced traction suspension method. Kirschner wires were used for skeletal traction in all cases. These were ordinarily inserted in the operating room under local, procaine anesthesia. If there was occasion to change the position of the wire at a later date, however, this procedure was carried out on the ward. It is our feeling that the disadvantages of this method, as compared with plaster fixation, are the need for more scrupulous attention by the ward personnel, the difficulty of repeated portable roentgenologic examination, and the tendency to produce gravitational abscesses. In our opinion, however, these are more than compensated for by the far better fracture reduction which can be obtained when skeletal traction is used. It is also of advantage to have a wound readily available for examination in case of suspected infection without the risk of having to reapply a spica plaster and so endanger a satisfactory reduction.

After insertion of the wire, the extremity was suspended from a Balkan frame on an Army half ring splint with a Pierson leg attachment. (A Braun-Boehler frame was used in 2 instances.) The initial weight was 15 to 25 pounds, depending on the weight of the patient, but this was regulated from time to time as determined by roentgenologic examination. It cannot be emphasized too strongly at this point that unless frequent roentgenologic examination is made this method should not be used. Measuring the length of extremities with a steel tape may give an approximation of the adequacy of the treatment, but it is by no means even reasonably accurate and should not be relied upon. The first film after reduction was taken at the end of 48 hours, and repeated films were made every few days thereafter until we were satisfied with the alignment of the fragments and the absence of either shortening or overpull. Afterward films were made at about 3 week intervals until bone union was observed. All patients had either fracture boards or strips of laced bamboo beneath the mattresses. The foot of the bed was elevated for countertraction.

In 43 patients, 60 per cent, the Kirschner wire was inserted through the tibial tubercle, and in 29, 40 per cent, it was placed through the lower femur at the junction of the shaft and condyles. There are definite advantages in each of the two wire positions, and we learned to make use of them whenever possible. We did not hesitate to change the position of the wire from femur to tibia and vice versa when this seemed desirable. When this step was taken, the second wire was inserted and the weight applied before the first wire was removed.

In general, tibial wires are to be preferred in all fractures through the lower third of the femur. Very often the location of the wound is such that the use of the wire through the femur is precluded. Even when this is not the case, it is very difficult to control a short lower fragment by a

wire through the lower femur. Anterior angulation usually occurs; this can be promptly corrected by placing the wire through the tibia. There was evidence of widening of the knee joint as a result of tibial traction in only 2 cases (Fig. 1). The wounds in both of these patients were severely infected with no hope being held for subsequent joint motion.

The most difficult deformity to correct in lower femoral fractures was persistent posterior angulation. This often could not be overcome by flexion of the knee or by manipulation. It was found that, with the wire through the tibial tubercle, the hinge of the Pierson attachment at the fracture site instead of at the knee, and with both the line of traction and the tibia maintained in the horizontal position, the posterior angulation was readily corrected (Fig. 2). This was the only type of case in which the line of traction was not made parallel with the shaft of the femur. It is important to maintain a firm support beneath the site of posterior angulation. A well padded Cramer wire splint placed on muslin slings and bent to the desired curve readily serves the purpose. The area must be carefully watched for signs of pressure irritation.

In fractures of the middle and upper thirds, the wire was inserted through the lower femur at the junction of the shaft and condyles and halfway between the anterior and posterior surfaces. We feel that control of the lower fragment is best obtained by the lowest insertion of the wire that can be accomplished without penetrating the knee joint. Placing the wire through the femur has the added advantage of permitting knee joint function at an earlier date. In fractures of the proximal third, marked flexion and abduction of the thigh are usually required; in addition, external rotation may be necessary. Middle third fractures require very little thigh flexion. In cases with knee joint infection, flexion of the knee was limited to 5 degrees in order to avoid persistent flexion deformities.

Satisfactory length and alignment were obtained by these methods in almost every patient admitted within 3 weeks of the original injury. Only an occasional manipulation of the fragments under anesthesia was required.

When the wire had been inserted through the femur, passive knee motion was begun at the end of 8 weeks. A rope and pulley arrangement was fastened to the end of the Pierson knee piece, and the patient was able to control the motion of his knee within the limits of comfort. Tibial traction cases obviously did not have knee motion until the wire was removed.

Skeletal traction was continued until there was roentgenologic evidence of bone union. Union occurred on an average in about 12 weeks. The wire was then removed and the patient maintained in suspension for an additional 2 weeks, during which time knee and hip motions were encouraged. Most of the American patients were immobilized in plaster at this point and sent by plane to the Zone of the Interior. The Chinese patients were kept in bed for an additional month and received daily massage and active and passive motions of the extremity. Quadriceps exercises were stressed from the beginning of treatment. Guarded weight-bearing was permitted only after 18 weeks, but it was impossible to control many of the Chinese patients, some of whom began to walk at the end of the 14 week suspension period. Several refractures were the result of early weight-bearing, and these delayed convalescence considerably. No leg braces were available at this time.

There were remarkably few complications resulting from the wire traction. There were no soft tissue or bone infections at the site of the wires. Only one wire snapped, and this occurred at the end of 12 weeks' traction. Three tibial wires pulled out into the soft tissues and had to be replaced. This accident was caused by too superficial insertion of the wire into the tibial tubercle. In one case the traction bow became loose from one end of the wire, and the wire was pulled out through the other side by the weights. This occurred at the end of 8 weeks, and there were no ill effects, further traction being unnecessary.

Residual stiffness of the knee was a problem in many cases. It is impossible to determine which cases will develop this stiffness; length of immobilization is not the only factor. Personal variation in the willingness of the patients to co-operate, their ability to tolerate discomfort and their desire to get well, are qualities of major importance. Early active and passive motion of the knee is certainly to be encouraged. Physical therapy must be regular and intensive. Gradually increasing manipulation of the knee by the physical therapist, with the patient prone and the fracture site supported, was useful and did not produce any untoward results.

Forceful manipulation of the knee under anesthesia, however, was disappointing. Tears of the quadriceps mechanism were produced in 2 cases, which further delayed the patient's convalescence. Even when improvement in knee motion was obtained, it was always fleeting, since increased postoperative discomfort militated against the patient's maintaining the increased range of

Fig. 1. Widening of the knee joint due to traction through the tibial tubercle in a supracondylar fracture with septic arthritis.[1]

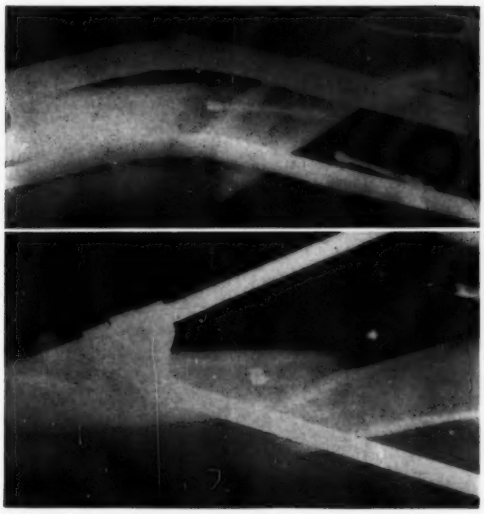


Fig. 2. a, Marked posterior angulation of fracture of distal third of femur. Persistent deformity on Braun-Boehler splint. b, Satisfactory alignment obtained by placing joint of Pierson leg attachment under the fracture and making traction in the line of the tibia.

motion. In several cases the result was a poorer functioning joint than before the manipulation.

Wedge plasters were more productive of beneficial results. In cases with limited flexion, a circular plaster was applied from ankle to groin, and muslin hinges were incorporated in the plaster on either side of the knee. An elliptical window was removed from the plaster behind the knee, and a transverse incision was made in it anteriorly. Each day the anterior opening was enlarged by blocks of wood and the range of flexion gradually increased. Care was taken to extend the knee completely each day before increasing the wedge in order to avoid the possibility of ending with a knee which had increased flexion but could no longer be extended. In the reverse situation, when there was limitation of extension with consequent faulty weight-bearing, wedge plasters were also helpful, the window being placed anterior to the knee and the joint gradually extended.

COMPLICATIONS

Thrombophlebitis. The diagnosis of thrombophlebitis was made in only 2 instances. One of the deaths was shown at autopsy to be due to a pulmonary embolus secondary to a thrombophlebitis of the pelvic veins on the side opposite the femoral fracture, and associated with an osteomyelitis of the ilium. The other instance was diagnosed after the patient became ambulatory, when swelling of the leg was noted and palpation revealed definite evidence of a thrombosed femoral vein.

Secondary hemorrhage. Secondary hemorrhage was noted in 4 instances, 5 per cent. One occurred 3 days after injury. At operation a popliteal artery which had been severed in battle was found. Gas gangrene, not recognized previously, was also discovered at operation and necessitated amputation. The patient died within 12 hours, probably from toxemia, since blood loss was minimal. Two cases had wounds involving the femoral artery which bled 6 and 10 weeks, respectively, after injury. In both cases the artery was ligated and satisfactory collateral circulation was established. The last patient of this group did not bleed until 16 weeks following injury. At operation a false aneurysm of the femoral artery was found. This was repaired, but subsequent amputation below the knee was required because of deficient circulation. It is interesting to note that in all 4 patients, the ankle pulses were palpable on admission and that the circulation at that time seemed adequate. Secondary hemor-

[1]Photographs by First Medical Museum and Arts Detachment.

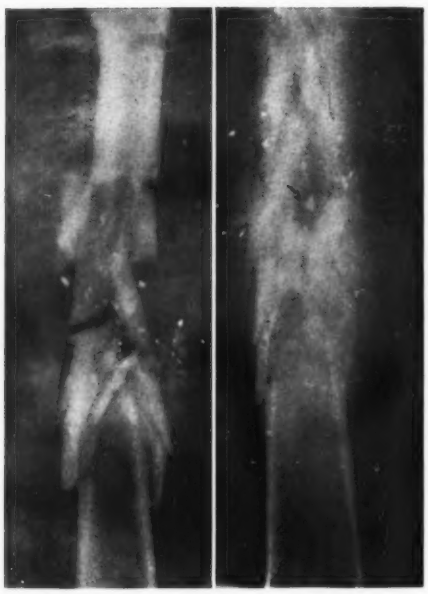


Fig. 3. a, left, Comminuted fracture of middle third of femur with multiple metallic fragments. b, Same case at 12 weeks. Typical example of low grade localized osteomyelitis with sequestrum.

rhage was always considered an absolute indication for immediate exploration of the wound.

Refracture. In 6 patients, 7 per cent, refracture occurred, usually following some minor trauma. One developed while the patient was still in traction, during an epileptic seizure. These patients were treated either by plaster fixation or reapplication of wire traction. Five of them obtained eventual bone union, and the sixth was returned to the Zone of the Interior before this could be determined. Of the 6 refractures, 5 were in patients having definite bone infection. We feel that we erred in applying the same criteria for length of immobilization in the bone infection cases as in the clean cases. The former should have been given a longer period of fixation. The

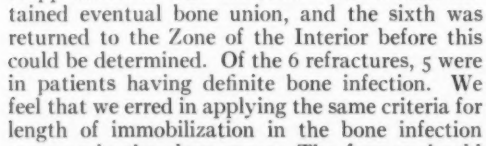


Fig. 4. Nonunion due to very marked loss of bone.

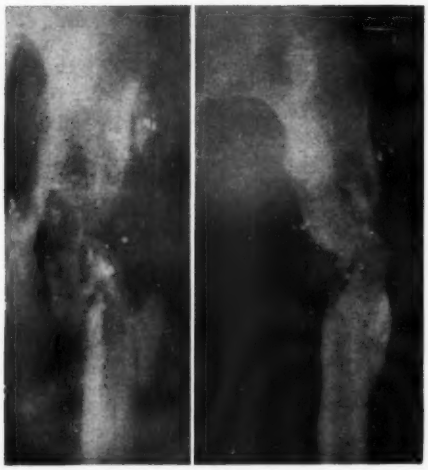


Fig. 5. a, left, Early film of severely comminuted fracture with marked bone loss. b, Film taken 9 months later shows solid bone union.

use of leg braces might have prevented some refractures, but they were not then available.

Bone infection. Bone infection of some degree developed in 23 patients, 28 per cent. Unless associated with septic arthritis of the knee, this was not a difficult problem. Bone union eventually occurred in all but one who had massive bone loss. His case is discussed later. Of the 22 remaining cases only 2 showed significant delay in bone healing, as shown roentgenologically.

With one exception, which was diagnosed by persistent drainage and the operative removal of a sequestrum, these cases showed x-ray evidence of localized osteomyelitis. The films did not reveal in any instance a spreading type of bone infection. In no case did a metastatic abscess develop. Figure 3 is a typical example of the minimal type of bone infection which was encountered. It is possible that the local and general use of the sulfonamides has modified the course of the bone infection as shown clinically and by films; surely no very serious infection was observed.

The only operative procedure which was, we considered, indicated in these bone infections was incision and drainage, with or without sequestrectomy. Often this was done in the ward with the patient still in traction, usually under pentothal anesthesia. Posterior drainage by counter-incision is very important, and the possibility of gravitational abscess must be kept in mind.

A draining sinus was the only persistent abnormality in this group. Sometimes it remained as

long as 10 months, and it is certain that some of these patients will require further surgery.

We have analyzed the various factors which might conceivably influence the occurrence of infection. Among these factors are: anemia, the presence of metallic foreign bodies, the interval which elapsed between injury and débridement, and coincident penetration of the knee joint. As almost all patients had débridement and sulfonamide therapy it was difficult to assess their value in the prevention of infection except by impression. When the other factors are tabulated, it is found that, with two exceptions, there is no significant difference between the cases in which infection developed and those in which it did not. The average hemoglobin level on admission was 11 grams in the cases which remained free of infection and 7 grams in the infected cases. This emphasizes the importance of early replacement of blood loss by whole blood transfusions. Second, when the fracture communicated with the knee joint, the likelihood of bone infection was increased threefold. It is our belief that the adequacy of the débridement is the most important single factor in the prevention of infection. It would appear from our data that the "golden period" for débridement has been extended by the use of the sulfonamides, since we found the incidence of infection in the patients débrided less than 12 hours almost identical with those débrided more than 12 hours.

Septicemia. In all cases with prolonged febrile course or severe toxicity, blood cultures were taken, but in none was there evidence of septicemia. In none could the diagnosis be made on clinical grounds.

RESULTS

Mortality. There were 4 deaths in the group, an overall mortality of 4.9 per cent (Table I). Two were from diseases not directly related to the fractured femurs. One patient was found on admission to be suffering from a severe dysentery and died from peritonitis secondary to perforation of ulceration in the colon of unproved etiology. At autopsy, no infection at the fracture site was found. The other died of pulmonary embolism following a sequestrectomy done for osteomyelitis of the pelvis on the side opposite the femoral fracture. The 2 remaining patients died of gas gangrene. Both of these had amputations which were performed too late. Earlier operations might have saved both lives. One arrived in a plaster spica 2 days after injury. The seriousness of the infection was not recognized until 24 hours later, when a mild secondary hemorrhage demanded exploration of the wound. The other arrived 7 days following a perforating bullet wound which had not been débrided. A transfusion, given in preparation for operation, resulted in a severe hemolytic reaction, with chill, prolonged hypotension, and subsequent jaundice, hemoglobinuria, and oliguria. The only chance for saving this patient was lost by waiting for recovery from this reaction rather than operating immediately. When operation was performed, 4 days after admission, he was in such poor condition that the result was inevitable; blood transfusion should have been used as an adjunct to operation rather than preparation for it.

TABLE I.—RESULTS

	No.	Per cent
1. Mortality		
a. Pulmonary Embolism	1	
b. Bowel perforation	1	
c. Gas gangrene	2	
Total	4	4.9
2. Amputations		
a. Gas gangrene	2	
b. Arterial injury	1	
Total	3	3.7
3. Bone union (of 74 cases)	71	96
4. Functional results (of 67 cases)		
a. Good	45	67
b. Fair	16	24
c. Poor	6	9
5. Cause of results other than good		
a. Stiff joint		
Hip	2	
Knee	9	
Total	11	
b. Shortening and angulation	4	
c. Nonunion	3	
d. Sciatic nerve injury	4	

Amputations. Two of our 3 amputations were performed because of gas gangrene. The third followed repair of a false aneurysm of the femoral artery. The latter patient made an otherwise uneventful recovery.

Bone union. Of the 78 patients who lived there was one amputation, and 3 patients were transported to the Zone of the Interior before the end-results could be determined. Of the 74 remaining cases, 71, or 96 per cent, showed clinical and roentgenologic evidence of bone union. Two cases of nonunion had massive loss of bone (Fig. 4). In the other instance, a clean case, the cause was unexplained. While the great majority of fractures united in from 12 to 14 weeks, some were observed for 8 to 10 months before we were satisfied that union was secure. There was surprisingly satisfactory union in several cases with marked bone loss (Fig. 5).

Functional results. American patients were returned to the States too early to judge the

functional results. The Chinese, however, were kept in the hospital long enough for us to estimate with reasonable accuracy their degree of functional recovery. There were 3 deaths in this group, and, of the 67 remaining patients, 45, or 67 per cent, had good functional results. In 16, or 24 per cent, the result was only fair and in 6, or 9 per cent, it was definitely poor.

The chief cause of unsatisfactory results was residual stiffness of the joints, especially the knee. There were 11 such cases. Shortening, angulation, and nonunion accounted for an additional 7 cases, and 4 patients had sciatic nerve injury.

SUMMARY OF IMPORTANT POINTS

An intensive study of 82 gunshot fractures of the femoral shaft incurred in action in the North Burma campaign of 1943-1944 revealed the following points worthy of emphasis:

1. The function of the forward surgical groups is the treatment of shock and hemorrhage, adequate débridement of wounds, institution of prophylactic chemotherapy, immobilization of fractures, and early evacuation. Definitive treatment of fractures should be reserved for the fixed installations.

2. In the prevention of infection, the most important single factor in the early treatment of wounds is the adequacy of the débridement.

3. A spica plaster is a satisfactory method of temporary immobilization. Nonpadded plasters should not be used, but, if used by necessity, they should be split through their entire length before transportation.

4. No ankle or instep hitches should be used in connection with Army leg splints.

5. Early inspection of the wound at the fixed medical installation is advisable to rule out infection, especially by gas-forming organisms. Afterward, dressings should be reduced to a minimum.

6. Incision and drainage should be instituted early when there are knee joint infections or deep subfascial abscesses. Dependent counter incisions are necessary.

7. Circulatory impairment is serious and not uncommon. It must be recognized early and the cause eliminated.

8. Anemia, malnutrition, and the effects of exposure must be combatted. Early replacement of blood loss by whole blood transfusion improves the general condition of the patient and helps to prevent infection.

9. Balanced skeletal traction suspension is a very satisfactory method of treating these patients in a fixed installation.

10. When traction suspension is used, the possibility of gravitational abscesses should be watched for and early drainage should be accomplished.

11. Kirschner wires through the lower femur and upper tibia proved very satisfactory, and there were no untoward effects. Each location has its advantages for certain types of fracture. The wires should be changed from one location to another when indicated.

12. Posterior angulation of lower femoral fractures can be corrected by placing the wire through the tibial tubercle and making traction in the line of the tibia instead of the femur.

13. Repeated roentgenologic examination is essential in treating these cases by traction suspension. Overpull must be avoided.

14. When there is associated knee joint infection, flexion of the patient's knee in the traction suspension apparatus should be limited to 5 degrees.

15. Traction should be continued until there is roentgenologic evidence of bone union. The average time for bone union was 12 weeks. Knee joint motion should be encouraged after 8 weeks.

16. Forceful manipulation of the knee is of no value and may do harm. Wedge plasters, however, are of considerable assistance in the relief of persistent joint stiffness.

17. Secondary hemorrhage from a wound, however slight, is a positive indication for immediate exploration.

18. Refractures usually heal, but convalescence is considerably prolonged thereby. Patients with precarious union should be kept in suspension for an added length of time. Afterward, leg braces should be used when they are available.

19. Bone infection did not predispose to nonunion, nor did it significantly delay the time of bone union as seen on the roentgenograms. However, refracture in these cases must be avoided by a longer period of immobilization than in the clean cases.

20. The osteomyelitis seen in our cases was localized, minimal, and easily controlled. It is possible that it was limited by the use of sulfonamides.

21. Retained metallic foreign bodies did not appear to predispose to bone infection.

22. There was a mortality of 4.9 per cent. Bone infection of some degree was noted in 28 per cent. Bone union occurred in 96 per cent of the survivors. The known functional end-results of 67 followed cases were good in 67 per cent, fair in 24 per cent, and poor in 9 per cent.

THE DIAGNOSIS OF ACUTE FLEXOR TENDON TENOSYNOVITIS

WILLIAM R. MOSES, M.D., Washington, D.C.

THE greatest difficulty in the care of infections of the hand is the diagnosis and differentiation of the types." This statement was made by Kanavel, who also remarks concerning tenosynovitis, "This type of infection is much more difficult to recognize (than lymphangitis) and the surgeon is often in doubt as to whether he is dealing with a lymphangitis or a tenosynovitis." He might well have added, "or both."

Thus does one of the fathers of hand surgery express the uncertainty of exact diagnosis in many cases of these grave infections. However, the correct treatment of tenosynovitis is surgically the exact opposite of that of simple lymphangitis and allied conditions of the hand; therefore, an exact diagnosis must nonetheless be made if the indifferent results so often attending the care of these infections are to be improved. Irreparable damage is the penalty for late or faulty diagnosis.

As outlined by Kanavel, the cardinal signs and symptoms of acute tenosynovitis are (1) exquisite tenderness over the course of the sheath limited to its distribution, (2) the semiflexed attitude of the finger, (3) exquisite pain on extension, and (4) symmetrical swelling of the entire finger.

Several difficulties, however, may and do detract from the specificity of this syndrome. An analysis of these signs reveals that they are not pathognomonic either singly or in combination. This may be demonstrated clinically by experience or by logical scrutiny. The first sign of tenderness limited to the sheath is camouflaged by the frequent association of tenosynovitis with such additional lesions as dermatitis, cellulitis, lymphangitis, burn or other trauma, or hematoma. Furthermore, there is an occasional case encountered in which only a part of the sheath is involved, as mentioned by Cutler. Second, the semiflexed attitude is that adopted by patients with any acute disease of the finger because this is the position of rest for the part. Third, the pain on extension is as characteristic of cellulitis or lymphangitis as of tenosynovitis because either flexion or extension of the digit will result in a distinct distortion of the soft parts inducing pain when these are tender. Finally, symmetrical swelling is found usually in simple lymphangitis.

From the Surgical Service of the Gallinger Municipal Hospital.

Fig. 1. Actual flexion of involved finger is prevented by the engagement of the nail of the finger in the thumb nail of the examiner. Attempted flexion produces pain along the palmer aspect of the finger in the presence of acute tendon sheath infection.

There remains, however, a method of examination which is a more direct approach to the tendon sheath. This test may be practiced in the following manner as illustrated. The nail of the involved finger is engaged in the thumb nail of the examiner in such a manner that *actual* flexion (and thereby compression of the soft tissues) is not allowed. The patient is then asked to *attempt* flexion of the member. It will be seen in the accompanying photograph that the examiner's forefinger may be used to steady the dorsum of the finger. In the presence of acute tendon sheath infection, acute pain is experienced along the palmar aspect of the finger due to the bowstring like tensing of the tendon against its sheath. Pain is consistently absent in infections involving the soft parts alone.

The author has used this test of differentiation in 23 consecutive cases of acute tenosynovitis, simple and complicated by other lesions as above mentioned. It appears to be a specific test.

REFERENCES

1. Cutler, C. W., Jr. The Hand. Philadelphia: W. B. Saunders Co., 1942.
2. Kanavel, Allen B. Infections of the Hand. Philadelphia: Lea & Febiger, 1943.

A D Ballou

EDITORIALS

SURGERY
Gynecology and Obstetrics

FRANKLIN H. MARTIN
Founder and Managing Editor
1905–1935

LOYAL DAVIS, EDITOR

Associates

SUMNER L. KOCH MICHAEL L. MASON

DONALD C. BALFOUR, *Associate, Editorial Staff*

JANUARY, 1946

ALBERT D. BALLOU
AN APPRECIATION

THE initial issue of SURGERY, GYNECOLOGY AND OBSTETRICS was published on July 1, 1905 with 600 paid subscriptions registered and a leading article written by Nicholas Senn. The trials and tribulations of the initial issue of the Journal have been written by Dr. Franklin Martin. As the Journal increased in popularity and number of subscribers it became certain that a man with a knowledge of printing and bookmaking must be chosen as General Manager. Many young men applied for the position; Albert D. Ballou was chosen. This was in 1907.

Educated in Iowa, the son of a Methodist minister, and trained for a career in journalism, Mr. Ballou has occupied the position of General Manager of the Surgical Publishing Company of Chicago for the past 38 years. His modesty, loyalty, business sagacity and ability to build an organization which has been welded together through the years by a spirit of friendliness, co-operation, and mutual respect have played a large rôle in the success of the Journal. He and his associates have been completely responsible for the format of the Journal, its attractive appearance, and the high standards of its advertising material. The wisdom of his judgment and the clearness of his vision are reflected in its pages.

To Mr. Ballou, Dr. Martin gave the task of organizing the mechanics of the first Clinical Congress of Surgeons in 1910. With each succeeding Clinical Congress, even after it became a part of the activities of the American College of Surgeons in 1913, he has discharged his responsibilities with great credit to himself and to the College of Surgeons. His meticulous fulfillment of tasks given to him, regardless of their magnitude or their relation to his primary responsibility, has always enlisted the profound admiration of his colleagues. Few laymen have such an extensive friendship among the surgical profession as he has.

The Board of Regents of the American College of Surgeons and the Board of Directors of the Surgical Publishing Company, as the time approached for his retirement, desired to record their appreciation of his invaluable service and to congratulate themselves upon the fact that his judgment and advice will still be available to them. It is their hope that the esteem and regard in which they hold him, and their deep appreciation of a task of great magnitude well done, will give added pleasure to his enjoyment of the future.

Irvin Abell.

Chairman, Board of Regents, American College of Surgeons; Chairman, Board of Directors, The Surgical Publishing Company of Chicago.

STRICTURES OF THE COMMON DUCT

STRICTURES of the common duct have always been a great problem to surgeons because results of repair have been so poor and their causation is usually related to an operation on the bile tract. In a study of patients with stricture, Cattell noted a relationship to operative trauma in about 80 per cent of cases and Walters in 90 per cent of cases. In a study made recently at Illinois Research Hospital, such a relationship was present in 76 per cent of cases.[1]

It is no doubt true that in many instances the damage may have been done by infection or an abscess and not by actual trauma. Nevertheless there are so many instances in which actual section or ligation of the duct can be proved that it behooves all surgeons working on the biliary tract to take extra precautions for safety of the ducts during operation upon the biliary system.

From the standpoint of treatment, the lesions can be divided into four major groups: (1) local stricture which can be resected with primary anastomosis; (2) stricture of the terminal end only, allowing transplantation of the proximal stump into the pylorus or duodenum; (3) stricture of the proximal portion, allowing preservation of the sphincter of Oddi; and (4) destruction or stricture of the entire duct. Repair of the first two types is comparatively simple and results will be good if certain pitfalls are avoided. For example, in group 1 it is desirable to do the anastamosis over a rubber or vitallium tube, but if a T-tube is used it must not be brought out through the repair line, but through an incision in the duct distal to it. In group 2 reformation of a stricture will be prevented to a great extent if the mucosa of the common duct is anastamosed directly to the mucosa of the intestine (Cattell). In groups 3 and 4, the vitallium tube as introduced by Pearse can be used to advantage. Search should always be made for the distal end of the common duct since the sphincter of Oddi is such a valuable factor in prevention of regurgitation of intestinal contents into the bile ducts. It is difficult to explain the mechanism of production of the stricture in group 4, and particularly the high frequency of this type. We have been unfortunate in finding an unusually large incidence of this type at Illinois Research Hospital, encountering this type in over half of 24 cases of inflammatory or traumatic stricture. If search is thorough, one can usually find the terminal duct or its remnant. We have not found incision into the duodenum for visualization of the sphincter of Oddi to be of much value to us. In almost all of our cases in group 4 we have found either a duct too small for function or one entirely obliterated. In view of multiple observation on a few cases, we are convinced that this obliteration can be gradual, and can be produced by infection and disuse.

Because of the frequency and difficulty in repair of group 4, we have devoted most of our attention to this group. We have tried anastamosis to the duodenum or pylorus of the stump of the duct at the hilus of the liver with so many failures that we have abandoned it. All patients repaired after this fashion do well for 6 months to 2 years, but ultimately all except one or two of ours have returned with serious symptoms of recurrence of the stricture.

For this reason we began the use of a vitallium tube to bridge the defect, but did not think it would be feasible to transplant the tube into a loop of intestine which was functioning; theoretically, the food stream would

[1]Cole, W. H., Ireneus, Carl, and Reynolds, John. Ann. Surg. (In press).

dislodge the tube. We accordingly adopted the principle of anchoring the tube to the stump of the duct at the hilus of the liver with a pursestring suture, and inserting the tube into a defunctionalized loop of jejunum. In 5 cases we inserted the tube into a loop of jejunum, the arms of which were anastamosed, hoping to shunt the food away from the tube, thus minimizing possibility of regurgitation of food and intestinal contents into the intrahepatic ducts. To our surprise, in the 4 patients who survived this operation, the food stream continued to flow through the arm of jejunum. All 4 patients developed cholangitis with chills and fever, which was fatal to one. Two of the three remaining had the proximal arm of jejunum severed and valves made in the distal arm. These two patients have had complete freedom from chills and fever, indicating that regurgitation of food was the primary cause of cholangitis.

Having had poor results with the use of a loop of jejunum, we later adopted the use of a defunctionalized arm of jejunum, utilizing the Roux principle. We have operated on 7 patients after this technique. This method is similar to one recently reported by Allen except that he used a rubber catheter instead of a vitallium tube and made no valves to prevent regurgitation. All 7 patients survived this operation, but one died 2 years after operation with Banti's disease, which we assume to be entirely coincidental. All 6 patients surviving have had excellent results, 2 or 3 of them having had one or two mild chills early in their convalescence.

We obtained such definite evidence of the rôle of regurgitation of food into the intrahepatic ducts in the development of cholangitis that we have arrived at the conclusion that 2 or 3 valves created by infolding of the intestinal wall (or equivalent method) should be placed in the arm of jejunum to prevent regurgitation and that at least 18 inches of jejunum should intervene between the anastamosis at the hilus of the liver and the end-to-side anastamosis of the jejunum.

On two occasions, x-ray observation at intervals has revealed passage of the vitallium tube after a few months. However, both of these patients have remained entirely well. In these cases, at least, the value of the tube could have been nothing more than temporary. Nevertheless, we are convinced that a temporary support of some type is absolutely essential for a few weeks, to maintain an opening and prevent shrinkage or possibly a true stricture at the junction of the hilus and arm of jejunum. It appears logical to assume that if the opening was small or stricture formation developed, the tube could not pass on account of the flange and funnel shaped tip. On the other hand, after the sutures had cut through (which we assume would happen in a few weeks with release of the tube), the tube might be passed if the opening was large enough to allow passage of the flange and funnel-shaped end. If the opening is this large, after the process of healing and scarring has been complete, the chance of stricture formation would appear minimal indeed. For this reason, we believe that if the tube remains in place for 3 months, it makes no difference whether it remains or passes, since the opening would appear sufficiently large to avoid stricture formation if large enough to allow passage of the tube after that interval. WARREN H. COLE.

INTRAVENOUS AMINO ACIDS, PROTEIN DIGESTS—ACCURACY OF TERMINOLOGY

THE intravenous injection of nitrogenous substances for nutritional purposes has received widespread attention in the past several years. It is to the credit of surgeons that as a group, they have

played a prominent rôle in the development of this field which is more closely related to the fundamental sciences than to clinical surgery.

In the literature concerning the practical application of intravenous nutrition with nitrogenous materials the terms "amino acids" and "casein" or "protein" digests seem to have been employed interchangeably. This is confusing, especially to the chemists. A solution of amino acids is just that and is prepared by addition of these acids each in crystalline form obtained synthetically or by extraction. A protein may be decomposed to its constituent amino acids but the writer is unaware of a digest generally available at this time in which this has been accomplished. The several types of available digests represent mixtures of simple peptids *and* amino acids. It has not yet been demonstrated that utilization of intravenously administered digests and solutions containing only amino acids are identical phenomena. Indeed, it has not yet been determined which type of preparation is the most desirable.

Now that the general principles have been established, it falls to the chemists further to improve nitrogenous nutriments for intravenous use. In doing this they must take cognizance of clinical research with the several types of solutions employed. In the interests of accuracy and to facilitate a general agreement in the manner of recording experiences, the consistent use of "casein," "fibrin," and similar terms, digest should be employed where such solutions have been used. The term "amino acid solutions" should be reserved for solutions composed of these acids only. The terms mentioned should not be employed indiscriminately as they refer to different preparations. ALEXANDER BRUNSCHWIG.

THE SURGEON'S LIBRARY

REVIEWS OF NEW BOOKS

THE third edition of Titus' *Management of Obstetric Difficulties*,[1] like the first two editions, is not intended as a conventional textbook. However it has been made more complete, particularly as regards an extensive bibliography. The emphasis on the practical, nevertheless, has been maintained and its aim as a working aid in dealing with obstetric emergencies preserved. Additions and changes have been made so as to bring this third edition grossly up to date. For example, the Rh factor and erythroblastosis are thoroughly discussed; caudal analgesia is included in the chapter on anesthesia; the techniques of extraperitoneal cesarean section are nicely described and illustrated; and penicillin therapy is completely discussed in practical detail.

Because it covers mainly the abnormal phases of obstetrics, minimizing historical and therapeutic considerations, and because it presents in a straightforward manner the practical aspects in the treatment of these abnormal phases, it should be available to all who may be faced with obstetric difficulties in practice or in training. It is of unlimited value to the general practitioner and to the obstetric house officer or resident. During my own hospital training the previous editions of this text were of the greatest aid, particularly in emergencies where a quick reference was needed. The author has expressly intended this book to serve just such a purpose; consequently, he has avoided lengthy discussions of all the possible forms of therapy in any given situation, and has frankly expressed his own preferences which are based upon years of clinical experience and which are nearly universally acceptable. This book is a "must." STUART ABEL.

THE fourth edition of *Essentials of Body Mechanics; in Health and Disease*[2] by Goldthwait, Brown, Swaim, and Kuhns has decreased in size, but has become more compact and concise while still retaining its clarity. The book is more timely now than ever, since there is so much stress on physical fitness nationally. The great number of rejections that occurred in Selective Service showed the necessity for more stress on physical fitness throughout the country. The need for rehabilitation of the returning service men, as well as the great problem of correcting so many of the deformities and disabilities seen in civilians, make this book of importance in this connection also. Many of the deformities in adult life could be prevented by establishing good body mechanics in childhood.

The advantage to the individual with chronic illnesses, in the correction of body mechanics, is demonstrated in several chapters of the book. In this connection the work of Kerr, showing the relationship of the heart and circulation to body mechanics is particularly interesting. The importance of keeping the aged in good physical condition, which will improve their general well being, is greater since the life expectancy has been definitely increased.

The chapter on the foot has been rewritten. The most common static deformity, pes valgoplanus, is conceived of as being a congenital defect in many instances, with the second toe longer than the first and the mechanism at the great toe more pliable than normal. The treatment described is by means of a series of exercises for the foot, in sitting and standing positions. To protect the weak foot, arch supports are recommended. EMIL D. W. HAUSER.

A timely contribution to an important branch of surgery, especially under war time conditions, is Armstrong's *Bone Grafting; in the Treatment of Fractures*.[3]

The author, a meticulous worker, has excellent qualifications from the viewpoints of training, assignment, experience, and associations.

The value of bone-grafting in the treatment of fractures is well known. In the practice of this particular branch of orthopedic surgery one, inevitably, is confronted by many problems and practical difficulties. This book has arisen out of the difficulties the author has encountered.

In the foreword, Mr. Watson Jones states that the principles of bone-grafting were familiar to John Hunter two hundred years ago. He further states: "In his monograph of bone-grafting in the treatment of fractures Mr. Armstrong's work reflects the surgical development of two hundred years—the research of Hunter, the work of Lister, the inspiration of Macewen, the skill of Lane, and the craftsmanship of Albee. On this very sure foundation, linked to recent research in metallurgy, is based a technique of bone-grafting which almost completely solves the problem of slow union, delayed union, and non-union." Mr. Armstrong has dealt faithfully with every detail of technique that the surgeon must know. As a leading member of the team of ortho-

[1] MANAGEMENT OF OBSTETRIC DIFFICULTIES. By Paul Titus, M.D. 3d ed. St. Louis: The C. V. Mosby Co., 1945.

[2] ESSENTIALS OF BODY MECHANICS; IN HEALTH AND DISEASE. By Joel E. Goldthwait, M.D., F.A.C.S., LL.D., Lloyd T. Brown, M.D., F.A.C.S., Loring T. Swaim, M.D., John G. Kuhns, M.D., F.A.C.S. 4th ed. Philadelphia: J. B. Lippincott Co., 1945.

[3] BONE GRAFTING; IN THE TREATMENT OF FRACTURES. By J. R. Armstrong, M.D., M.Ch., F.R.C.S. Baltimore: The Williams & Wilkins Co., 1945.

pedic surgeons of which the Royal Air Force is proud, surgeons who have shouldered heavy responsibility, he with them has gained vast experience, and treated the fractures of pilots and aircrews which are characterized by remarkable severity and multiplicity. In all their work the highest possible standard has been set, and it has been maintained by the vigilance of Osmond Clarke, a service consultant. But it has been achieved without standardization or suppression of initiative.

The technique of onlay bone-grafting with vitallium screw fixation is well established. Brilliant results can be achieved—deformity can be prevented, union can be accelerated, nonunion can be avoided. But, let it be remembered that John Hunter was defeated by sepsis. Let it be remembered that internal fixation was no more than part of the contribution made by Arbuthnot Lane; no-touch technique was the other part. Even today the general standard of asepsis in operative technique is far too low. To infect a closed fracture is a disaster of the first magnitude; it is no less worthy of a court of inquiry than a railway disaster. The surgeon who proposes to adopt the recommendations of Armstrong's monograph must first achieve so perfect a command of aseptic technique that if, within a few days of operation, the patient develops a febrile reaction he can say with complete confidence: "He may have pleurisy, he may have pneumonia, but whatever he has, I am quite certain that he has no infection in the wound."

Armstrong believes that the onlay graft technique is the simplest and most efficient. The most effective available grafts are those cut from a normal tibia. The use of metal screws is the most reliable method of securing internal fixation.

He outlines certain basic considerations such as: close and stable contact between large areas of raw bone on the graft and host; mechanically stable fixation of the graft and fracture; before grafting, the clearing of the fractured surfaces of fibrous tissue and sclerotic tissue; restoration of normal apposition and alignment of the fragments of the host bone. The architecture of the reconstructed bone as a whole should as far as possible at the conclusion of operation approximate normal.

Subjects discussed are the principles, general indications, contraindications; types, sources and fixation of grafts; preoperative and postoperative treatment; operative technique; cutting and preparation of grafts; fractures of the spine, clavicle, humerus, radius, ulna, carpal scaphoid, metacarpals and phalanges, neck of the femur, shaft of the femur, tibia, fibula, ankle, tarsus and metatarsals.

Arthrodesis has been discussed in connection with certain fractures of the tarsus and spine in which he believes it to be the best initial treatment.

Most of the roentgenograms and the statistics included in the Appendix were taken from the records of the Royal Air Force orthopedic centers. The author acknowledges the debt which he in common with all the other orthopedic surgeons in the Royal Air Force, owe to Mr. Watson-Jones and to Air Commodore Osmond Clarke. He pays tribute to every member of the orthopedic "team" in the center to which he is attached.

Those who will receive the greatest benefit from this book are the surgeons who have: (1) the qualifications to do this type of work, (2) the interest, (3) the opportunity, and (4) adequate facilities to do it well, including physical set up, medical, surgical and allied personnel and equipment.

Minor criticism includes the thought that the double onlay graft has not been given sufficient space and illustration. Some of the colored illustrations are too highly colored. Some photographs are only fair; line drawings would have been more instructive. However, in spite of these criticisms, the book can be recommended without reservation.

PHILIP LEWIN.

A CONCISE presentation is made in *Hypertension and Hypertensive Disease*[1] of the authors' concepts of hypertension and hypertensive disease with a critical analysis, almost approaching dogmatism, of many existing ideas on the genesis and management of these disorders. The material is well presented with considerable space devoted to functional evaluation and its bearing on the rationale of certain forms of therapy.

In the early chapters hypertension is defined and hypertensive disease is discussed. The authors consider essential hypertension as an indefinable physiologic disturbance (or disturbances) characteristic of this disease which ultimately leads to elevation of diastolic and systolic blood pressures, anatomical changes in the vascular tree, and functional impairment of the involved tissues. They feel that in the past physicians have been too interested in the level of the blood pressure and have neglected the primary cause. After considering the factors capable of altering blood pressure, they conclude that the responsible agent is a generalized vasoconstriction sufficient to increase the total effective peripheral resistance. The authors tend to show that although a humoral mechanism with a superimposed neurogenic factor is generally believed to cause vasoconstriction, controversial data exist which prevent this concept from being a reality.

This section is followed by a critical analysis of the renal mechanism in the genesis of human hypertension. They oppose the inference that experimental (induced) and human (spontaneous) hypertension are the same. Their conclusions are based on a detailed analysis of the cases in the literature in which bilateral and unilateral intrinsic renal disease in humans was considered the primary mechanism. By their own strict criteria a rare instance was allowed but the majority of cases were not accepted. Renal ischemia was also eliminated as the cause for hypertension in pregnancy.

[1] HYPERTENSION AND HYPERTENSIVE DISEASE. By William Goldring, M.D., and Herbert Chasis, M.D. New York: The Commonwealth Fund, 1944.

The chapter on the evaluation of the current medical and surgical treatment is too critical as the authors' criteria for evidence of cure is rigid and almost impossible so long as the cause of hypertension remains unknown. Anything which merely depresses the blood pressure is considered artificial when no attempt is made to combat the cause. Thiocyanate therapy was not recommended as it proved dangerous in their hands. They admitted that pyrogenic substances lowered the blood pressure but this was offset by the undesirable effects upon cardiovascular dynamics. Renal extracts were considered empirical, inasmuch as the authors believed that the fall in pressure resulting from their administration was probably associated with a pyrogenic reaction. Nephrectomy was definitely condemned. The newer concepts of amine-oxidasis treatment were described.

The reader, however, is given some ideas as to treatment for a regimen is suggested which is conservative and logical. The management of hypertensive complications especially in pregnancy are worthy of comment.

Appendixes are included at the end of the book which describe the technique of determining direct blood pressure measurements, cardiac output, and the various procedures used for determining renal function.

THEODORE R. VAN DELLEN.

THE author of the volume, *Radiologic Examination of the Small Intestine*,[1] because of his scientific interest and tremendous experience, is one of the few qualified to deal with this important subject. Much of the material has been presented at instructional courses at the meetings of the American Roentgen Ray Society and the Radiological Society of North America. Those of us who have had an opportunity to attend these courses are indeed grateful that the author provided the profession with this fundamental material in the form of a book for study, reference, and reflection.

It has only been in comparatively recent years that any time or consideration has been given to the small intestine during a gastrointestinal examination. In most books published on the subject of the gastrointestinal tract little space is devoted to the small bowel. The author has had a wide experience in this field and has made every effort to correlate the roentgen with clinical, operative, and postmortem observations. A thorough knowledge of the anatomy and physiology is paramount if one is properly to evaluate the roentgen findings and to differentiate the normal from the abnormal.

The author in his usual clear, concise, easily readable, and scientific manner devotes the first chapter to indications for roentgen examination, technique, and the report of the small intestine study followed by a thorough description of the embryology, anatomy, and physiology of the small bowel. He then describes the appearance of the normal small bowel in the adult and the infant. Subsequent chapters are devoted to organic lesions such as intestinal obstruction, the use of the Miller-Abbott tube in the diagnosis and treatment of ileus, disorders of nutrition, diseases of the mesentery, allergy, inflammations, neoplasms, anomalies, the effect of food and certain drugs on the small intestine, and miscellaneous conditions. All of these conditions are discussed thoroughly with due credit given to the work of other investigators. The subject matter is well illustrated with excellent reproductions in the negative phase. An extensive bibliography is a further testimonial to the author's scientific approach to the subject.

This volume, written by a man well qualified and completely familiar with the subject, represents a truly outstanding contribution to the literature in the field of roentgenology. It should be in the library of every roentgenologist and any physician interested in the diagnosis of lesions of the intestinal tract. The publishers are to be congratulated on the excellence of the paper, the printing, and the illustrations. It is recommended without reservation.

EARL E. BARTH.

THE second edition of *Clinical Roentgenology of the Digestive Tract* by Maurice Feldman[2] which presents a clinical roentgenological consideration of diseases of the gastrointestinal tract has been thoroughly revised and completely reset. The importance of the diagnostic value of the roentgen examination is stressed throughout. The subject is handled in a lucid, concise manner, well illustrated with excellent reproductions of roentgenograms and artists' drawings.

Separate chapters are devoted to the esophagus, stomach, duodenum, small intestine, colon, hernia, diaphragm, appendix, gall bladder, biliary ducts, liver, pancreas, peritoneum, omentum, mesentery and retroperitoneal tumors, lymphomatous diseases, abdominal vessels, spleen, the deficiency diseases, and miscellaneous conditions. A systematic co-ordination and correlation of the clinical and roentgenological findings is emphasized in the discussion of every condition. The more recently described developments and methods of x-ray examination have been added. A complete bibliography is provided at the end of each chapter.

The author is to be congratulated for assembling such a vast amount of material into a single volume, thus providing a source of accurate information on this important subject. The reviewer has found the first edition published in 1938 to be one of the most useful books in his library as an atlas for the medical students and as a helpful reference work providing a valuable and ready source of accurate information. The second edition is recommended without reservation to roentgenologists, gastroenterologists, students, and general practitioners. The book should be added to the library of any physician

[1] RADIOLOGIC EXAMINATION OF THE SMALL INTESTINE. By Ross Golden, M.D. Philadelphia: J. B. Lippincott Co., 1945.

[2] CLINICAL ROENTGENOLOGY OF THE DIGESTIVE TRACT. By Maurice Feldman, M.D. 2d ed. Baltimore: Williams & Wilkins Co., 1945.

interested in the accurate diagnosis of lesions of the gastrointestinal tract. EARL E. BARTH.

IN simple, concise words the author's forty years of experience and teaching in the field of traumatic surgery is skillfully described in *Clinical Traumatic Surgery*.[1] The valuable material in Dr. Moorhead's earlier books—*Traumatic Surgery* in 1917, and *Traumatic Therapy* in 1931—has been included and brought up-to-date by the excellent appraisal and discussion of improvements in the treatment of the injured. Chemotherapy and penicillin, early mobilization, Roger Anderson reduction apparatus and Stader splints, as well as many other advances are considered. The work is unusually well illustrated by photographs, diagrammatic sketches, many describing stages of treatment procedures such as reduction of the dislocated hip or the dislocated shoulder. The reproductions of x-ray films are not only excellently chosen, but the reader can actually see the pathological condition described.

The 32 chapters, covering 725 pages with 500 illustrations, divide the field of traumatic surgery into logical categories in which the reader can quickly learn exactly where to find any particular type of traumatic problem discussed. The chapters on traumatic neuroses, medicolegal phases of trauma, compensation problems and malpractice suits, reveal the author's knowledge of the importance of these subjects in all traumatic surgery treatment. The chapter on war injuries is a fine abbreviated résumé of treatment of war injuries, including much of the author's experience at the Pearl Harbor attack December 7, 1941, where he just happened to be at that time. One would expect Dr. John J. Moorhead to dedicate this book to "The Wounded at Pearl Harbor—In recognition of their courage and stamina and in tribute to their surgeon-comrades."

This book offers an excellent opportunity for the physicians on duty in hospital receiving and examining rooms to study this field and should be there for ready reference. It should also be in every industrial medical department and dispensary for treatment of the injured. Since the general practitioner may occasionally or frequently be called upon to treat cases of injury, the volume offers an excellent ready source of reliable information.

One gains the impression of overcrowding of the pages necessitated by publication of this book under war-time restrictions. Future editions that are certain to follow quickly, I am sure, will correct this condition, where, for example, a new chapter follows the preceding chapter within an inch or two of the bottom of the page. EDWARD C. HOLMBLAD.

THE book, *The Care of the Neurosurgical Patient* by Ernest Sachs,[2] containing 268 pages with 177 illustrations, two in color, is considerably broader in its scope than the title suggests. It is evidently written for the enlightenment of neurosurgical internes and young residents. From this standpoint it fulfills its mission well. The older neurosurgeons will find much of interest, whether or not they agree on minor details, as the book reflects the mature opinion of one of the pioneers in this comparatively new specialty. However, the chief function of this work is the instruction of the novice. It is filled with simple truths, common sense observations, and, what to the experienced neurosurgeon may seem trivial or self-evident facts, but which to the young man without such a background are valuable directives.

These are the simple instructions presented, knowledge of which we usually take for granted and cannot understand why the inexperienced fail to make the necessary observations and carry out the indicated procedures. Sachs anticipates the many simple complications which may arise before, during, or after a neurosurgical operation and gives detailed instructions to prevent or relieve them.

The book is written in almost a conversational manner which in some places leads to verbosity. The reviewer at times felt the desire to condense or eliminate sentences—to get more rapidly to the essential facts.

The first chapter deals with the preoperative examination and care of most neurosurgical conditions. Included is an outline of a very complete neurological examination and the special tests to be made in the diagnosis of certain intracranial tumors. Under separate headings, which are carefully indexed, are suggestions for the examination and early care of patients with head injury, brain tumor, brain abscess, neuralgia, hydrocephalus, spinal injury, spinal tumor, ruptured intervertebral disc, spina bifida, and peripheral nerve injury.

Subsequent chapters deal with the operating room, preparation of the patient, and general operative procedures. Included is a discussion of anesthesia, neurosurgical practices in the control of hemorrhage, the use of suction, cotton, and bone wax. The indications for and technique of ventriculography are given.

Two chapters are devoted to operative procedures, usually with details of illustrative cases in which such operations were performed. Sachs presents his personal views, gleaned from a wealth of material and years of practice, as to the best procedure for a wide variety of neurosurgical conditions. Perusal of these by the inexperienced interne or resident, especially just before assisting in the operating room, would greatly enhance his value, since he would know in general what was being done and could anticipate some of the needs of his chief. All the usual neurological surgery operations are well illustrated.

An excellent chapter deals with postoperative care, a subject so often delegated to comparatively inexperienced men. Included is the care of the

[1] CLINICAL TRAUMATIC SURGERY. By John J. Moorhead, B.S., M.D., D.Sc., F.A.C.S. (D.S.M.). Philadelphia: W. B. Saunders Co., 1945.
[2] THE CARE OF THE NEUROSURGICAL PATIENT BEFORE, DURING AND AFTER OPERATION. By Ernest Sachs, A.B., M.D. St. Louis: The C. V. Mosby Co., 1945.

bowels and bladder, postoperative fever, the recognition of a postoperative clot, frequency of dressings, and other simple, but from the patient's standpoint, important details.

A careful study of this work by the young resident staff will remove a considerable load from the neurosurgeon and will undoubtedly expedite the recovery of many patients. Max M. Peet.

THE breast may well be considered the organ of romance for more reasons than one. It responds to many influences; sexual maturity with its accompanying hereditary or basic variances, the menstrual cycles, pregnancies either going to term or interrupted, lactation, brief or prolonged, intercurrent infections, pelvic disease affecting ovarian secretion, early or late in life, the menopause and subsequent senile involutional changes. The anatomical changes in the breast due to the above influences are so varied that, in truth, it is difficult to determine accurately what is within the normal and what is abnormal when one considers evolutional changes which might present themselves in the largest number of relatively healthy individuals. The breast is an external organ therefore susceptible to fairly accurate evaluation of gross anatomical changes, and with slight inconvenience material can be procured for microscopical examination. The examination of the breast is a real art that must be developed in the light of gross and microscopic studies that are properly interpreted. An answer to many of these perplexing problems may be found in the new second edition of *Diseases of the Breast* by Geschickter.[1]

This, the second edition, follows the first which appeared a few years ago and which was considered by many to mark a milestone in monographic medical literature. New material has been added in this second edition chief of which is the criteria of operability and inoperability of mammary carcinoma, the relative merits of surgery and irradiation in cancer, the endocrine therapy of chronic cystic mastitis, and the etiology of mammary carcinoma. This new edition of approximately 800 pages contains 593 illustrations and many tables.

It is impossible to review adequately this work because of the tremendous amount of material it contains. The basis for opinions and conclusions by the author is placed upon a study of clinical cases seen in the wards of the Johns Hopkins Hospital, a critical analysis of case histories, specimens, and follow-up studies recorded in the Surgical Pathological Laboratory of the Johns Hopkins Hospital and experimental evidence obtained by the author in his own investigative work and that of others. Included is a description of the normal development and functional changes in the mammary gland, the endocrine physiology of the breast and the breast in pregnancy and lactation. The author seems to have simplified somewhat the subject of chronic cystic mastitis considering it as a mammary dysplasia of varying types. The endocrine aspects of this condition are discussed and, what is important, the possible rôle mammary dysplasia may play in the occurrence of cancer. It would appear that this latter is the prime factor since by far the largest percentage of breast lesions which are benign do not endanger the life of the patient nor do they markedly handicap the individual. It is the fear of the presence of cancer or the possibility that the lesion is the forerunner of cancer that distresses the patient. In consideration of this association between chronic cystic mastitis and carcinoma, the author states in the preface of this second edition: "The incidence of carcinoma in chronic cystic mastitis (less than three per cent) has been supported by additional statistics and the importance of endocrine factors in the etiology of benign and malignant mammary neoplasms has been extensively confirmed."

Many pertinent facts are presented in the discussion of benign mammary tumors in the light of estrogenic stimulation. In 328 pages devoted to a complete consideration of cancer of the breast, reference is made again to the importance of recognizing a thorough radical mastectomy as the treatment of carcinoma of the breast in the so-called operable stage. One point the author brings forth is difficult to comprehend. In advising irradiation after radical mastectomy when axillary nodes are present, he states that there is about 5 to 7 per cent increase in the 5 year survival over that procured with only the radical mastectomy. It would seem logical to conclude that by far the largest percentage of deaths due to carcinoma of the breast are the result of distant metastases such as to the viscera and not to purely local recurrences. The question involved is whether such fatal visceral metastases are the result of local recurrences or whether they were present or took place at the time of the radical mastectomy. If the former then postoperative irradiation might be of benefit but if the metastases were present at the time of operation irradiation will be of no final benefit. Serious consideration must be given to events that may occur when the patient is examined while the diagnosis is made, such an excessive manipulation of the breast, thus spreading the disease, and possible spread during the operation.

The experimental evidence on production of mammary dysplasias and tumors including carcinoma is extremely interesting. One cannot escape the conviction that the promiscuous adminstration of hormones especially the estrogen group may have potential dangers. This warning may be timely now when there seems to be a trend to give women estrogenic substances for so many resistant conditions and complaints that do not yield to commonplace therapy.

The author has without doubt accomplished his purpose which is well expressed in the preface to the first edition; "In recent years contributions to the

[1] Diseases of the Breast. By Charles F. Geschickter, M.A., M.D. With a special section on treatment in collaboration with Murray M. Copeland, A.B., M.D., F.A.C.S. 2d ed. Philadelphia, London, Montreal: J. B. Lippincott Co., 1945.

etiology, the diagnosis and the treatment of mammary disease have accumulated rapidly. Much of the progress made can be attributed to the different groups of specialists interested in these problems. The specialties concerned include surgery, radiology, obstetrics and gynecology, pathology, endocrinology and laboratory technology. In bringing together in this volume the work done in these diverse fields, the usefulness of this information to the general practitioner as well as to the specialties enumerated has been the foremost in mind." In this volume there is placed at the disposal of the practitioner an enormous amount of information that he must have if he expects fully to comprehend his responsibilities and escape the pitfalls before him when diagnosing and treating diseases of the breast. The many excellent illustrations add much to the text.

JOHN A. WOLFER.

BOOKS RECEIVED

Books received are acknowledged in this department, and such acknowledgment must be regarded as a sufficient return for the courtesy of the sender. Selections will be made for review in the interests of our readers and as space permits.

A TEXTBOOK OF SURGERY. By American Authors. Edited by Frederick Christopher, B.S., M.D., F.A.C.S. 4th rev. ed. Philadelphia and London: W. B. Saunders Co., 1945.

PATHOLOGY OF TROPICAL DISEASES; AN ATLAS. By J. E. Ash, Colonel, M.C., U.S.A., and Sophie Spitz, M.D., C.S., A.U.S. Philadelphia and London: W. B. Saunders Co., 1945.

A MANUAL OF SURGICAL ANATOMY. Prepared under the Auspices of the Committee on Surgery of the Division of Medical Sciences of the National Research Council. By Tom Jones and W. C. Shepard. Philadelphia and London: W. B. Saunders Co., 1945.

AMPUTATION PROSTHESIS; ANATOMIC AND PHYSIOLOGIC CONSIDERATIONS, WITH PRINCIPLES OF ALIGNMENT AND FITTING DESIGNED FOR THE SURGEON AND LIMB MANUFACTURER. By Atha Thomas, M.D., F.A.C.S., and Chester C. Haddan. Philadelphia, London, Montreal: J. B. Lippincott Co., 1945.

CLEFT PALATE AND SPEECH. By Muriel E. Morley, B.Sc., F.C.S.T. Baltimore: A William Wood Book. The Williams & Wilkins Co., 1945.

THE 1945 YEAR BOOK OF RADIOLOGY. DIAGNOSIS. Edited by Charles A. Waters, M.D., and Whitmer B. Firor, M.D. THERAPEUTICS. Edited by Ira I. Kaplan, B.Sc., M.D. Chicago: The Year Book Publishers, Inc., 1945.

TRATAMIENTO ACTUAL DE LAS HERIDAS; CIRUGIA SULFAMIDAS PENICILINA. By Pedro D. Curutchet. Buenos Aires: Libreria y Editorial "El Ateneo," 1945.

WAR NEUROSES. By Roy R. Grinker, Lt. Col., M.C., and John P. Spiegel, Major, M.C., A.A.F. Philadelphia and Toronto: The Blakiston Co., 1945.

MODERN UROLOGY FOR NURSES. By Sheila Maureen Dwyer, R.N., B.S., and George W. Fish, M.D. With a foreword by Helen Young, R.N. Philadelphia: Lea & Febiger, 1945.

STUDIES ON PROTEIN METABOLISM IN THE CELLS OF EPITHELIAL TUMOURS. By Torbjörn Caspersson and Lars Santesson. Stockholm: Kungl. Boktryckeriet. P. A. Norstedt & Söner, 1942.

EXPERIMENTS WITH MAMMALIAN SARCOMA EXTRACTS IN REGARD TO CELL-FREE TRANSMISSION AND INDUCED TUMOR IMMUNITY. FURTHER STUDIES OF THE KREBS, RASK-NIELSEN, WAGNER SARCOMA. By Carl Krebs, Oskar Thordarson & Johannes Harbo. Aarhus: Aarhus Kommunehospitals Rontgen & Lysklinik Og Radiumstationen For Jylland, 1942.

THE VALUE OF THE BARIUM ENEMA IN THE DIAGNOSIS AND TREATMENT OF INTUSSUSCEPTION IN CHILDREN, Illustrated by about Five Hundred Danish Cases. By Jens Munck Nordentoft. Copenhagen: Einar Munksgaard, 1943.

URETHROCYSTOGRAPHY IN THE MALE WITH SPECIAL REGARD TO MICTURITION. By Nils P. G. Edling. Stockholm: Kungl. Boktryckeriet. P. A. Norstedt & Söner, 1945.

POSTURAL CIRCULATORY AND RESPIRATORY CHANGES DURING ETHER AND INTRAVENOUS ANESTHESIA. AN EXPERIMENTAL ANALYSIS OF THE SIGNIFICANCE OF POSTURAL CHANGES DURING ANESTHESIA WITH SPECIAL REGARD TO THE VALUE OF THE HEAD-DOWN POSTURE IN RESUSCITATION. By Torsten Gordh. Stockholm: Esselte ab Stockholm, 1945.

CEREBRAL ANGIOGRAPHY WITH PERABRODIL (CAROTIS ANGIOGRAPHY). By Arne Engeset. Oslo: Fabrritius & Sønners Boktrykkeri, 1944.

RENAL TUBERCULOSIS AND ROENTGENOLOGIC EXAMINATION. A SURVEY AND A COMPARISON BETWEEN THE EFFICIENCY OF THE DIFFERENT DIAGNOSTIC METHODS IN SIXTY CASES OF SURGICAL RENAL TUBERCULOSIS, WITH A SPECIAL VIEW TO THE ROENTGENOLOGIC DIAGNOSTIC. By Ragnar Steinert. Oslo: Grøndahl-Trykk, 1943.

THE MUSCULAR BUILD AND MOVEMENTS OF THE STOMACH AND DUODENAL BULB, ESPECIALLY WITH REGARD TO THE PROBLEM OF THE SEGMENTAL DIVISIONS OF THE STOMACH IN THE LIGHT OF COMPARATIVE ANATOMY AND EMBRYOLOGY. By Johan Torgersen. Oslo: Fabrritius & Sønners Boktrykkeri, 1942.

THE RADIOSENSITIVITY OF THE BONE MARROW. By Torfinn Denstand. Oslo: Centraltrykkeriet, 1943.